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Soil Survey of Iowa, Report No. 78—Monroe County Soils

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SOIL SURVEY OF IOWA

MONROE COUNTY

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND MECHANIC ARTS

Agronomy Section
Soils Subsection

Soil Survey Report No. 78

September, 1936

Ames, Iowa

IOWA AGRICULTURAL EXPERIMENT STATION

Soil Survey Reports

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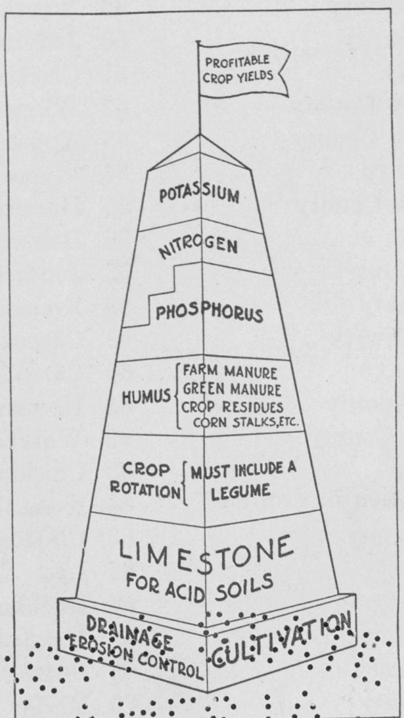
By P. E. Brown, C. L. Orrben, H. R. Meldrum and A. J. Englehorn



IOWA AGRICULTURAL
EXPERIMENT STATION
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MONROE COUNTY SOILS[1]

By P. E. Brown, C. L. Orrben, H. R. Meldrum and A. J. Englehorn

Monroe County is located in southern Iowa in the second tier of counties north of the Missouri state line and in the fourth tier west of the Mississippi River. It is entirely within the Southern Iowa loess soil area and the soils are, therefore, practically all of loessial origin. The only drift soils found are those derived from the old Kansan till which has been exposed through the erosion or washing away of the loessial covering.

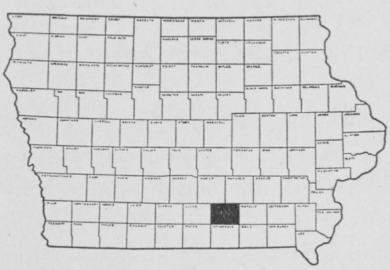


Fig. 1. Map showing location of Monroe County.

The total area of the county is 432 square miles or 276,480 acres. Of this area 264,494 acres, or 95.7 percent, are in farm land. The total number of farms is 1,708 and their average size is 155 acres. Owners operate 53.9 percent of the total farm land and renters the remaining 46.1 percent.

The following figures taken from the Iowa Yearbook of Agriculture for 1932 show the utilization of the farm land of the county:

Acreage in general farm crops	113,265
Acreage in farm buildings, public highways and feedlots	10,209
Acreage in pasture	135,728
Acreage in waste land not used for any purpose	4,357
Acreage in farm woodlots used for timber only	2,355
Acreage in crop land lying idle	1,689
Acreage in crops not otherwise listed	71

THE TYPE OF AGRICULTURE IN MONROE COUNTY

The type of agriculture practiced most generally in the county at present consists of a combination of livestock and grain farming which is characteristic of the general farm. Corn is the chief crop grown and hay and oats are of secondary importance. There are small acreages in wheat, barley, rye, alfalfa and soybeans and occasionally some flax is grown. Garden and fruit crops are of very minor importance. The raising and feeding of beef cattle is the most important of the livestock industries. Dairying has been increasing in recent years and is now of considerable importance. Hog raising is an industry which has always been popular and it has increased to some extent in the last few years. Poultry raising is an important source of farm income and more and more attention is being paid to it. In general, the income on the farms is derived from the sale of livestock and livestock products with a considerable portion coming from the sale of surplus crops, particularly corn, in some instances.

There is a large acreage in waste land in the county, some of which might be made more productive than it is at present. In many cases the land has been

[1] See Soil Survey of Monroe County, Iowa, by C. L. Orrben of the Iowa Agricultural Experiment Station and W. E. Tharp of the United States Department of Agriculture. Field operations of the Bureau of Chemistry and Soils, Series 1931, Project No. 245 of the Iowa Agricultural Experiment Station.

so seriously eroded that it is practically worthless for general farm crops. In such cases it should be planted to trees or seeded down to permanent pasture if it is possible to do so. Where the land is not being cultivated because of previous mismanagement it can often be reclaimed and made productive by proper methods of soil management. General recommendations for the treatment of such land cannot be given as the needs are variable. Later in this report some suggestions are offered for the handling of the land in the various soil types, in order to make it more productive or to bring it back to a condition of satisfactory fertility. Advice will be given in special cases where the conditions are unusual, upon request to the Soils Subsection of the Iowa Agricultural Experiment Station.

The area in pasture in the county is high, amounting to 49 percent of the total area. The native pastures consist mainly of bluegrass. Some areas are timbered and others, while they have never been wooded, are badly eroded and suitable only for pasture purposes. The more heavily wooded areas offer little pasturage and some areas are in such poor condition that they are of little value until erosion is controlled and some pasture is established. Little attention has been given to pastures in the past and hence in many cases they are providing little feed. Overgrazing is one of the most common sources of injury to the better pasture areas. Some tame grass meadows are pastured after hay crops have been taken off for two seasons and this pasture supplements the permanent pasture areas in supplying feed for the livestock. There is a need for more attention to the pastures of the county and with proper treatment and carefully controlled pasturing, they may be made much more productive in many cases.

THE CROPS GROWN IN MONROE COUNTY

The crops grown in the county in the order of their importance are corn, hay, oats, wheat, soybeans, alfalfa, barley, rye and potatoes. The acreage, yield and value of these crops are shown in table 1.

Corn is the main crop grown in the area, both in acreage and value. It was grown on 19.12 percent of the farm land in 1932 and average yields of 35.2 bushels are recorded. The yields are much greater than this on the better soils which are well adapted to corn growing. The yields on the rougher land which is not suitable for corn, are often low. Such land is apt to be seriously eroded, too, when corn is grown on it. The yellow varieties of corn, including Reid Yellow Dent, Krug, Leaming and Iodent are preferred. Some strains of these varieties have been developed on individual farms. Hybrid corn is being used to some extent. The corn produced is used largely for feed on the farms, only small surpluses being sold.

Hay is the second crop in acreage and value in the county. Clover and timothy mixed is one of the most important of the hay crops. It was grown on 4.02 percent of the farm land in 1932 with an average yield of 1.08 tons per acre. All other tame hay was grown on 7.64 percent of the farm land and the average yields were 1.12 tons per acre. Very little wild hay is produced.

Alfalfa was grown on 0.37 percent of the farm land in 1932 with an average yield of 2.75 tons per acre. This crop will not grow without the addition of lime to the land, but, when the land is limed and well prepared, alfalfa is a valuable

TABLE 1. ACREAGE, YIELD AND VALUE OF PRINCIPAL CROPS GROWN IN MONROE COUNTY, IOWA*

Crop	Acreage	Percentage of total farm land of county	Bushels per acre or tons	Total bushels or tons	Average price**	Total value of crops
Corn	50,561	19.12	35.2	1,779,747	$0.12	$213,570
Oats	20,495	7.75	27.6	565,345	0.10	56,535
Winter wheat	2,953	1.11	11.7	34,474	0.33	11,376
Spring wheat	48	0.02	9.0	432	0.33	143
Barley	796	0.30	18.9	15,045	0.20	3,009
Rye	162	0.06	9.4	1,518	0.24	364
Clover and timothy hay (mixed)***	10,635	4.02	1.08	11,486	6.00	68,916
Alfalfa	938	0.37	2.75	2,580	8.00	20,640
All other tame hay	20,220	7.64	1.12	22,646	6.00	135,876
Wild hay	16	0.01	0.84	13	4.50	59
Soybeans sown with other crops	403	0.15	....	....	....	....
Soybeans sown alone	2,035	0.79	....	....	....	....
Soybeans harvested for beans	382	0.14	14.4	5,503	0.42	2,311
Potatoes	14	0.01	95.0	1,330	0.37	492
Timothy seed	2,874	1.09	4.4	12,512	0.95	11,886
Clover seed***	733	0.29	0.74	545	6.00	3,270

*Iowa Yearbook of Agriculture, 1932.
**Average state farm values Dec. 1, 1932, except alfalfa hay and clover seed, which are estimated.
***Sweet clover not included.

crop. Some sweet clover may be grown also on land which is limed and it makes a valuable pasture or green manure crop.

Some timothy is grown for seed and clover is also grown for seed in some cases. In 1932 the acreages used for this purpose amounted to 1.09 percent and 0.29 percent of the farm land for the timothy and clover respectively. The yields amounted to 4.4 bushels and 0.74 bushels per acre for the two crops.

Oats are grown mainly as a supplement to corn in the rotation and to serve as a nurse crop for the legume or hay mixture. In 1932 this crop was grown on 7.75 percent of the farm land and the average yield was 27.6 bushels per acre. In favorable seasons and on the better soils, the yields are often much greater than this. Late varieties are grown by most farmers, Richland, Albion, Iowar and Green Russian being the favorites. The oats crop is used mainly for feed for work stock or in the dairy cattle and hog rations. Little of the crop is sold.

Some winter wheat is grown, 1.11 percent of the total farm land being in this crop in 1932, with an average yield of 11.7 bushels per acre. There is a very small acreage of spring wheat in the county. The acreage in barley is limited and 0.30 percent of the farm land was used for this crop in 1932 with an average yield of 18.9 bushels per acre. Some oats and barley are grown together for feeding purposes.

Rye, flax, millet, soybeans and sorghum are minor crops. Soybeans, however, are becoming of more importance and in 1932 this crop was grown alone on 0.79 percent of the farm land. It was grown with other crops on 0.15 percent of the land. The crop was harvested for beans on 0.14 percent of the farm land.

Potatoes are grown on many farms, chiefly to supply the home demand, and average yields of 95 bushels per acre were reported in 1932. Other minor garden crops are grown on the farms to a very limited extent.

THE LIVESTOCK INDUSTRY IN MONROE COUNTY

The raising and feeding of beef cattle has been the most important of the livestock industries in the county since the land was settled. The large area in rough to strongly rolling land suitable only for pasture purposes makes this industry particularly adapted to the county. The feeders are purchased on the open market or in nearby localities and while some herds of Angus, Hereford and Shorthorn cattle are still found in the county, the number has decreased considerably and most farmers have preferred to purchase feeders. Recently the number of beef cattle has decreased owing to the abnormal conditions of the markets but it will probably be increased again with the return to normalcy.

Dairying is the second industry of importance in the area and it has become much more generally practiced in recent times. The herds consist of 15 to 35 cows where milk and milk products are the chief source of income. Most all farmers maintain a few cows. The introduction of good grade cows, purebred sires and improved methods of feeding have made dairying much more popular and profitable. Holstein-Friesian, Guernsey and Jersey or grades of these breeds are the most popular. The milk is sold to local creameries or to regular customers direct by the producers in the vicinity of the larger towns.

Hog raising has become more popular in recent years and is a very important livestock industry at present. To some extent it has replaced beef cattle raising and feeding. Duroc-Jersey, Hampshire, Poland China and crosses of these breeds are preferred. Brood sows are selected from the young animals each year and sires are purchased annually to head the herd and improve the stock. The income from the hog industry is considerable.

Horses and mules are grown on some of the farms to supply the needs for power. Only a few animals are raised. Tractors are used to some extent but horses and mules are depended upon mostly.

Poultry raising has come to be considered an important source of farm income and more attention is being paid to the management of the flocks. Poultry and produce houses in the towns receive most of the live poultry and eggs from the farms, although some of the poultry products are sold to buyers for the Chicago markets.

Some sheep and goats are pastured in the rougher areas where the land is producing poor pasture. Sheep raising is of some importance and might be followed more extensively to advantage in some sections of the county. Sheep may be grown and pastured on land which is too rough and too largely grown up to second-growth timber and bushes to be suitable for the best pastures.

THE FERTILITY SITUATION IN MONROE COUNTY

The yields of general farm crops on the more level, richer upland soils in the county are fairly satisfactory in most cases but even on these better soils, the yields of various crops may be increased considerably and a more profitable crop may be obtained by the adoption of better methods of soil management and by the use of certain methods of soil treatment. On the poorer lands the need of improved methods of management is evident. In many instances larger yields might be obtained by proper handling of the soils.

The drainage situation is not entirely adequate in all cases and wherever this is the case some attention to proper drainage should be the first consideration of the farmer. Drainage must be good if the best crop yields are to be obtained and no other treatments will be of any value on land which is too wet, until drainage has been provided. Some areas in the Grundy silt loam may need tiling, and in the Putnam silt loam and the Marion silt loam on the uplands, and in the Bremer soils on the second bottomlands artificial drainage may be needed.

The need for lime on the soils of the county is great. All the land is acid in reaction and liming is necessary for the best growth of all farm crops, especially the legumes such as sweet clover and alfalfa. In fact these crops and often others such as red clover will not grow until lime is added to the land. The soils should be tested regularly and at least once in the rotation preceding the legume crop, in order that the needed amount of lime may be added as required to permit the best growth of the legume crop. Furthermore, the soils should be kept well supplied with lime in order to provide the best conditions for the growth of all crops and to permit the maintenance of permanent fertility.

Some of the soils in the area are not very well supplied with organic matter as is indicated by their light color and poor condition of tilth. Such soils are obviously in need of additions of materials supplying organic matter and applications should be made in liberal amounts. Even on those soils which are not so apparently lacking in organic matter, additions at regular intervals are necessary if the supply is to be kept up. The Clinton soil loam, Shelby silt loam, Putnam silt loam and Marion silt loam on the uplands are particularly in need of additions of organic matter and the O'Neill fine sandy loam and Calhoun silt loam are terrace soils that are deficient in organic matter. The Lindley silt loam on the upland, when it is cultivated, is very seriously lacking in organic matter, but most of this type is in pasture or in timber. The application of organic matter to other soils, as the Grundy silt loam, Edina silt loam and Weller silt loam on the uplands and the Waukesha and Bremer soils and the Chariton silt loam on the second bottomlands would also be most desirable and large increases in crop yields would follow.

The chief source of organic matter is farm manure and this natural fertilizing material has large value as a fertilizer on the soils of the county, bringing about considerable increases in the crop yields. The proper use of all crop residues also helps materially in the maintenance of the organic matter content of the soils and these materials should always be used on the land because of their value. Legumes as green manures provide the main means of adding organic matter and improving the fertility of land on farms which are operated on a general farm, or grain farm basis and on which little farm manure is available to be added to the soil. Green manuring is a very important supplement to, or substitute for, farm manure. On the poorer soils and the sandy types, green manuring with legumes is particularly important. It is of double value when legumes, well inoculated, are used, as then nitrogen along with organic matter is supplied.

The content of phosphorus in the soils of the county is low and it is quite apparent that additions of this element in a commercial fertilizer will be necessary in the near future even if it is not absolutely required at present. The experiments which have been carried out with rock phosphate and superphosphate on soils similar to those in this county has shown quite definitely that the applications are of value for general farm crops and hence it seems that either one or the other phosphate fertilizer might be used at present on the soils of the area with profit. Either or both phosphates may be tested on individual farms to determine the actual value under the particular conditions pertaining to the farm and then applications may be made to more extensive areas on the farm with the assurance of profit. Tests on a small scale are quite desirable, but in general it has been found that either of the phosphates may be used successfully in normal seasons and will bring about large increases in crop yields and also improve the quality of the grain crops.

There are cases where the use of complete commercial fertilizers will undoubtedly prove profitable when properly used in the county, but in general it is felt at present that the use of a phosphate would probably prove quite as worth while and the cost would be less. Unless the complete fertilizer brings about a much larger crop increase than superphosphate, with which it is usually compared, the latter would prove more economically profitable. Tests comparing these two materials have shown very similar crop effects and hence it is recommended that tests comparing the two fertilizers be carried out on the farm before any complete commercial fertilizer is used at all extensively. Any complete brand may be tested on a small area with little difficulty and a comparison made with superphosphate applied in an equivalent amount of phosphorus and then the comparative crop effects along with the relative cost of the two materials will show definitely which should be employed under the particular farm conditions.

The use of commercial nitrogen fertilizers is not recommended for the soils of the county at the present time as it is felt that the nitrogen content of the soils may be built up and kept up much more cheaply and quite as satisfactorily by turning under inoculated legumes as green manures. This will also maintain the organic matter content of the soil. In small amounts as top dressings the use of some commercial nitrogenous fertilizer may be worth while but none should be used extensively until tests on a small scale have been made and the effects demonstrated. Similarly commercial potassium fertilizers are probably not needed in many cases in the county. There may be instances in which they would prove of value. Again tests on small areas are recommended before any extensive applications are made in order to be sure that the land will respond to the treatment and that the crop will be increased sufficiently to make the treatment profitable.

Erosion is an important factor in the proper handling of the soils of the county. In some cases there has been very extensive washing away of the surface soil and methods of erosion control are very much needed now. The Shelby and Lindley soils are the most seriously eroded types and wherever these soils are cultivated they should be handled in such a way as to prevent erosion. Other types may show some erosion and in such cases methods for erosion control are needed.

THE GEOLOGY OF MONROE COUNTY

In general the rock material underlying the soils of Monroe County is buried so deeply by the deposits of glacial drift and loess that it exerts little effect upon the present soil conditions. Only in one case is the soil formed from the native bedrock. The Dubuque silt loam is a residual soil, being formed from the limestone rock, and it occurs in many areas, chiefly in the northern part of the county on the steeper slopes to the streams. The areas are narrow and the land is largely non-agricultural, owing to the steepness of the slopes and to the very thin covering of soil remaining on the rock.

During the glacial age at least one great ice sheet passed over the county and, upon its retreat, it left behind a vast deposit of debris or glacial till known as the Kansan drift. An earlier ice invasion may have occurred but there is little evidence now to show it. The Kansan deposit was extremely variable in depth, ranging from a few feet to several hundred, averaging probably about 100 feet. This Kansan drift material consists of a mixture of clay, sand, gravel and boulders in varying proportions but the original material was probably a blue or gray clay mixed with some sand and gravel. The upper portion of the deposit has been changed by weathering until the color has become a yellowish-brown to reddish-brown or brown and there has been considerable removal of the original constituents by leaching. The Shelby silt loam and the Lindley silt loam are the soil types which have been formed from this drift deposit which has been exposed by the later removal of the loessial covering through the agency of erosion. These are important soil types in the county at present and are found on the rougher to strongly rolling or steep land.

Later in geological history when the conditions from the standpoint of climate were quite different than those at present, there was laid down over the surface of the land in the county, a deposit of wind-blown material, known as loess. This material was variable in depth, ranging from 4 to 15 feet in the different areas. It consists of a fine silt-like material which was originally a light grayish-brown to yellowish-brown in color. The accumulation of plant residues, however, has changed this color and at present the color may be a dark brown to black. In some cases the color is still very light. The native content of lime and other minerals has been completely or largely washed away and there has been some accumulation of finer clay particles in the subsurface soil and in greater amount in the subsoil. The Grundy, Edina, Weller, Putnam, Clinton and Marion soils are formed from this loessial material. The first three types are darker in color, having been formed under prairie conditions, while the last three soils are lighter in color, the Marion being almost white. There are distinct gray layers in the subsurface soils in the Putnam and Marion soils and often suggestions of gray layers in the Grundy and Edina soils. The subsoils are heavy in all these types.

The alluvial soils, first and second bottomlands, are found along the various streams of the county. They are composed of material of loessial and glacial origin and are extremely variable in composition both in the surface soil and in the subsoil. The bottomlands are subject to overflow while the terraces are well above overflow. The soils of the Waukesha, Bremer, Chariton, O'Neill and Calhoun series are second bottomland or terrace soils and the Wabash types are on the first bottoms.

PHYSIOGRAPHY AND DRAINAGE

In topography the land in Monroe County ranges from hilly to steep or broken along the streams to rolling on the narrower divides and more nearly level on the broader interstream areas. A comparatively narrow high divide extending from Lovilia southeastward through Albia and Moravia in Appanoose County, divides the county into two almost equal parts. Two narrow divides extend northeastward from Albia as branches of the main divide. The tops of the ridges rise to approximately the same elevation, roughly representing the surface of the plain before it was dissected by stream action and erosion to its present condition. With the exception of the divides the county is thoroughly cut by streams and the Des Moines River and its tributaries and the numerous large creeks and their tributaries reach every section of the county. All the streams have cut deep beds; the valleys are narrow and V-shaped with steep slopes and narrow bottoms. The flood plain of the Cedar Creek, the largest stream with the exception of the Des Moines River, rarely exceeds ½ mile in width. A few narrow terraces have been formed.

The most rugged land is in the northwestern part of the county where the stream valleys are deep and narrow, the slopes steep, the ridges eroded and narrow and erosion is still continuing to cut down the slopes and remove the tops of the

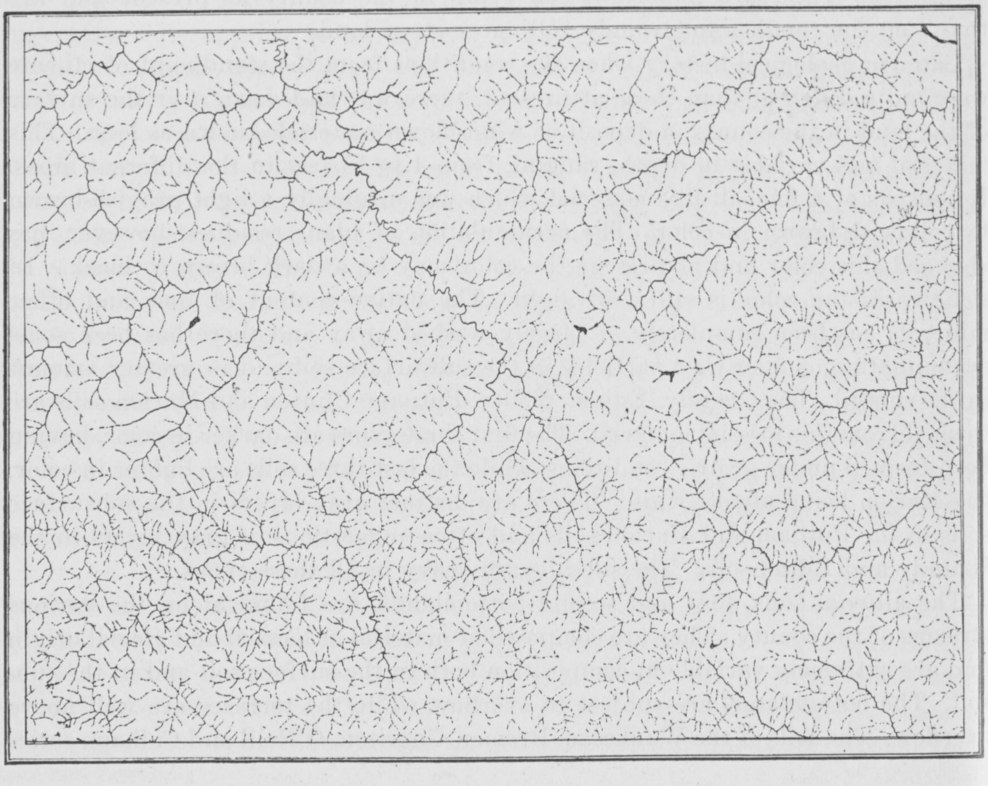


Fig. 2. Map showing natural drainage system of Monroe County.

ridges. Stream tributaries send drainage channels back into the sections. South of Tyrone the same condition exists but to a lesser degree. The relief over the remainder of the county is not so rugged. The slopes, although thoroughly drained, are longer and more gentle and the ridges more rounded, while narrow, flat areas remain along the tops of the ridges.

The drainage of the county is brought about by the Des Moines River which is the main stream, crossing the county in the extreme northeastern corner, and its tributaries, together with the Cedar Creek and its tributary streams. This creek enters the county from the west, flows eastward for about 10 miles and then meanders north by northwest into Marion County. Several other smaller creeks handle the drainage of the southeastern part of the county. The main tributaries of the Des Moines River include Miller Creek, Grays Creek, Avery Creek and Little Avery Creek. The chief tributaries of Cedar Creek are Whites Creek, English Branch, Bee Branch, and North Cedar Creek.

Except for relatively small areas in some of the uplands the natural drainage of the county is adequate. There are areas in the Grundy silt loam, the Edina silt loam, the Putnam silt loam and the Marion silt loam on the level uplands where there is need for artificial drainage in order to make the land more productive. Tiling is needed in these cases because of the level topography and the heavy character of the subsoil which prevents adequate underdrainage. There are also some areas on the terraces where drainage would be of value, particularly in the case of the Bremer and Calhoun soils. The Wabash types on the bottoms need protection from overflow if they are to be cultivated and in some instances require drainage also.

THE SOILS OF MONROE COUNTY

The soils of Monroe County are grouped into five classes on the basis of their origin and location. These groups are drift soils, loess soils, terrace soils, swamp and bottomland soils and residual soils. Drift soils are deposits made by the glaciers. They consist of materials varying widely in composition and containing sand and some gravel and occasionally boulders. Loess soils are fine dust-like deposits made by the wind at some previous geological age. Terrace soils are former bottomlands which have been raised above overflow by a decrease in the volume of the stream or by a deepening of the river channel. Swamp and bottomland soils occur in low-lying poorly drained areas or along streams and are subject to overflow. Residual soils are those formed from the underlying rock and remaining in place.

The occurrence of these groups of soils is indicated in table 2. Drift soils cover over one-third of the total area of the county — 37.8 percent. Loess soils are found on almost one-half of the area — 44.9 percent. Terrace soils are developed to a very minor extent, covering only 1.9 percent of the county. Swamp and bottomland soils cover 10.8 percent of the area and there is one residual soil which is found on 4.6 percent of the total area.

There are 18 individual soil types in the county and these with the area of riverwash make a total of 19 separate soil areas. There are 2 drift soils, 6 loess types, 7 terrace soils, 3 areas of swamp and bottomland soils and 1 residual soil. They are distinguished on the basis of various characteristics described in the appendix to this report. The type names denote certain group characteristics which will be discussed later. The areas of the different types are shown in table 3.

TABLE 2. AREAS OF DIFFERENT GROUPS OF SOILS IN MONROE COUNTY

Soil group	Acres	Percentage of total area of county
Drift soils	104,640	37.8
Loess soils	124,480	44.9
Terrace soils	5,120	1.9
Swamp and bottomland soils	29,568	10.8
Residual soils	12,672	4.6
Total	276,480	....

The Shelby silt loam is the larger of the drift soils, covering 23.4 percent of the total area of the county. It is the most extensively developed soil in the area. The Lindley silt loam is the second drift soil, covering 14.4 percent of the county. It is the third largest soil type in the area. The Grundy silt loam is the largest of the loess soils and it is the second largest type in the county. It covers 21.1 percent of the total area. The Weller silt loam is the second loess type, covering 13.1 percent of the county. It is the fourth largest type in the area. The Clinton silt loam is the third loess soil and the sixth largest type in the county. It covers 7.9 percent of the area. The Putnam silt loam is a minor type covering 1.7 percent of the county. It is the fourth largest loess soil. The Edina silt loam and Marion silt loam are minor loess soils, covering 0.7 and 0.4 percent of the total area of the county respectively.

The Bremer silt loam is the largest of the terrace soils, covering, however, only 1.1 percent of the county. The other terrace soils, of the Chariton, Calhoun, Waukesha, Bremer and O'Neill series, each cover less than 1 percent of the area. The Wabash silt loam is the largest bottomland soil and it is the fifth largest type in the county, covering 10.5 percent of the total area. The colluvial phase of the Wabash silt loam is very minor in extent, covering 0.2 percent of the area. The residual soil covers 4.6 percent of the county, being the seventh largest type in the area. There is a very small area of riverwash.

Some relationship between the topographic features of the land and the soil types on the uplands is indicated in the county. Thus the Shelby and Lindley soils are found on the rougher to steep land while the more strongly rolling areas fall into the Shelby, Clinton or Weller soils. The Grundy silt loam, the Edina silt loam, the Putnam silt loam and the Marion silt loam are found on the more level to very slightly sloping uplands where the loess soils are mapped. On the terraces the Bremer and Calhoun are found in the more level to flat or depressed areas and the Waukesha, O'Neill and Chariton soils are mapped on the higher terraces. The bottomlands show little or no topographic features. The Dubuque silt loam is found on the rougher areas bordering the streams, particularly in the northern part of the county.

TABLE 3. AREAS OF DIFFERENT SOIL TYPES IN MONROE COUNTY

Soil legend on map	Soil no.	Soil type	Acres	Percentage of total area of county
		DRIFT SOILS		
Ss	93	Shelby silt loam	64,640	23.4
Ls	65	Lindley silt loam	40,000	14.4
		LOESS SOILS		
Gs	64	Grundy silt loam	58,368	21.1
We	261	Weller silt loam	36,416	13.1
Cm	80	Clinton silt loam	21,824	7.9
P	66	Putnam silt loam	4,672	1.7
Es	211	Edina silt loam	2,112	0.7
M	67	Marion silt loam	1,088	0.4
		TERRACE SOILS		
B	88	Bremer silt loam	3,088	1.1
Ch	105	Chariton silt loam	768	0.3
Cl	42	Calhoun silt loam	384	0.1
Wk	60	Waukesha loam	256	0.1
Bs	43	Bremer silty clay loam	384	0.1
Ws	75	Waukesha silt loam	256	0.1
Of	110	O'Neill fine sandy loam	64	0.1
		SWAMP AND BOTTOMLAND SOILS		
Wl	26	Wabash silt loam	29,056	10.5
Wl x	26a	Wabash silt loam (colluvial phase)	448	0.2
Rv	43	Riverwash	64	0.1
		RESIDUAL SOIL		
Ds	183	Dubuque silt loam	12,672	4.6
		Total	276,480	....

THE FERTILITY IN MONROE COUNTY SOILS

The soils mapped in the county were all sampled and analyzed for plant food content except the Waukesha loam, the Waukesha silt loam and O'Neill fine sandy loam which were all so small in area that they were not sampled. The riverwash was not analyzed owing to its great variability and unimportance agriculturally. The more extensively developed soils were sampled in triplicate while the minor soils were represented by only one sample. All samplings were made with the greatest of care so that they would be thoroughly representative, free from local variations and not influenced by special treatments. The samples were taken at three depths — 0 to 6⅔ inches, 6⅔ to 20 inches and 20 to 40 inches — representing the surface soil, the subsurface soil and the subsoil respectively.

Total phosphorus, total nitrogen, total organic carbon, total inorganic carbon and limestone requirements were determined on all samples. Official methods were employed for the phosphorus, nitrogen and carbon determinations and the Truog qualitative test was used for the limestone requirement determinations. The results given in the tables are the averages of duplicate determinations on all samples of the soils.

The Surface Soils

The results of the analyses of the surface soils are given in table 4. They are calculated on the basis of 2 million pounds of soil per acre.

The content of phosphorus in the soils ranges from 619 pounds per acre in the Lindley silt loam up to 1,347 pounds per acre in the Bremer silty clay loam. The amount of the element present seems to be related to the soil group, at least as far as the upland and bottomland soils are concerned. The drift soils on the

TABLE 4. PLANT FOOD IN MONROE COUNTY, IOWA, SOILS
Pounds per acre of 2 million pounds of surface soil (0″–6⅔″)

Soil no.	Soil type	Total phosphorus	Total nitrogen	Total organic carbon	Total inorganic carbon	Limestone requirement
	DRIFT SOILS					
93	Shelby silt loam	727	3,080	40,932	....	6,000
65	Lindley silt loam...........	619	1,600	25,252	....	6,000
	LOESS SOILS					
64	Grundy silt loam...........	1,046	3,360	47,368	....	7,000
261	Weller silt loam............	1,010	3,080	37,509	....	7,000
80	Clinton silt loam...........	848	2,400	30,119	....	7,000
66	Putnam silt loam	889	2,840	36,596	....	7,000
211	Edina silt loam............	983	3,440	43,468	....	7,000
67	Marion silt loam...........	875	2,680	31,769	....	7,000
	TERRACE SOILS					
88	Bremer silt loam...........	1,266	2,680	37,305	....	4,000
105	Chariton silt loam..........	1,535	3,520	42,922	....	7,000
42	Calhoun silt loam	1,023	2,720	31,687	....	7,000
43	Bremer silty clay loam......	1,347	3,680	42,977	....	7,000
	SWAMP AND BOTTOMLAND SOILS					
26	Wabash silt loam..........	1,279	3,000	46,468	....	2,000
26a	Wabash silt loam (colluvial phase)	1,320	4,480	53,503	....	7,000
	RESIDUAL SOIL					
183	Dubuque silt loam..........	1,010	2,440	31,142	....	7,000

uplands are lower in phosphate than any of the other groups and the loess soils on the uplands are lower than the terrace soils or bottomland soils. The residual soil is lower than the latter groups, too. There is very little difference between the amounts present in the terrace and in the bottomland soils. It might probably be expected that the upland soils would be lower in the element than the first and second bottomland soils inasmuch as the latter are newer soils and have not been farmed so long nor so heavily as the upland types. Hence there has undoubtedly been a smaller removal of the phosphorus in crop growth, while the soils might have been originally equally well supplied.

There are some indications of a relationship of the amount of the phosphorus present to the soil series but as there is only one member of most series present in the county, these indications must not be taken too broadly. The Shelby silt loam is higher than the Lindley; the Grundy and Weller soils are higher than the other loess types; the Chariton and Bremer soils on the terraces are higher than the Calhoun silt loam, and the Dubuque silt loam is much the same as the upland loess types of the Grundy and Weller series. There is a suggestion of a relationship here to the color of the soil, the topographic position and the character of the subsoil, all characteristics which are important in the determination of the soil series. Soils like the Grundy and Weller which are darker in color are richer in phosphorus than lighter colored types like the Clinton, Putnam and Marion. The Bremer and Chariton soils which are darker in color are richer than the Calhoun which is light in color. The Shelby silt loam is higher in the element than the Lindley owing partly to its darker color. These two soils are lower than the loess soils because of their coarser textured subsoils and their rougher topographic position as well as their different origin. The Clinton soils are lower in plant food than the Grundy and Weller owing to their more strongly rolling to rough topography. The Bremer soils are richer than the Calhoun owing partly to their more depressed topographic position on the terraces. The first bottomland soils of the Wabash series are the richest in phosphorus because of their position, the fact that crop growth on them has been largely limited to pasture grasses or uncultivated crops and there has been little removal of plant food, their dark color which is due to the accumulation of organic matter, and their heavy subsoil condition which has prevented losses by leaching.

There is little evidence of the effects of texture on the content of phosphorus in these soils and owing to the fact that most of the types mapped are silt loams, no comparisons are available. Only in the case of the Bremer soils is there any occurrence of differently textured soils and here the silty clay loam is richer than the silt loam as is usually the case. In general it has been found that soils of finer texture in the same series are richer in plant food than those which are coarser. Thus silty clay loams are generally richer than silt loams while the latter are richer than loam or sandy loams. The sandy soils are apt to be the poorest in all plant food constituents.

All the soils of the county are quite evidently low in phosphorus and applications of phosphorus fertilizers must be made in the very near future even if they are not absolutely necessary at present. But there is evidence from experimental work, as will be noted later, of the value of phosphate fertilizers on these soils in many cases now and hence tests of rock phosphate and superphosphate are urgently recommended.

The total nitrogen supply in the soils varies from 1,600 pounds per acre in the Lindley silt loam up to 4,480 pounds per acre in the colluvial phase of the Wabash silt loam. There is little evidence of any relation between nitrogen content and the soil group, although the upland soils are somewhat better supplied, as would be expected, than the bottomland soils on which there has been much less removal of plant food by crops. The drift soils average somewhat lower than the loess soils but the wide difference in the amounts in the two drift types makes this comparison of little significance. The first bottomland soils likewise are a little higher on the average than the terrace soils, which might be expected.

There is considerable evidence of the influence upon the nitrogen content of the characters of the soil which determine the soil series. The color of the soil, the topographic position and the subsoil texture and condition are very important factors affecting the supply of the element, nitrogen. The darker-colored soils, those more level to flat in topography and those with the heaviest subsoils are the richest in nitrogen. Thus the Shelby silt loam is richer than the Lindley silt loam owing to its darker color. The Grundy silt loam and the Edina silt loam are higher in nitrogen than the Clinton silt loam owing to their more level topography, and also to their development under prairie conditions rather than under timber, which is another factor affecting the plant food content of soils. The Putnam and Marion soils are lower in nitrogen than the Grundy, Edina and Weller types owing to their lighter color. The Bremer soils are richer than the Calhoun types on the average owing to their darker color and similarly the Chariton silt loam is higher than the Calhoun because of its darker color. The colluvial phase of the Wabash silt loam is higher than the typical Wabash silt loam owing to its position and mode of formation from the wash from the adjacent uplands. In many cases it appears that the soil series characteristics will determine to a very large extent the content of nitrogen which is present in the soils.

There is little evidence of the effects of texture on the nitrogen in the soils, as most of the types mapped in the county are silt loams. The Bremer silty clay loam is richer in the element than the silt loam and this is the only exact comparison possible. It is generally the case that the finer-textured soils are higher in nitrogen than the coarse-textured soils. Thus silty clay loams are usually richer than silt loams which in turn are higher than loams or sandy loams. The latter are richer in nitrogen than sands.

The nitrogen content of some of the soils in the county is quite low as is indicated by their light color and poor physical conditions. In many cases the supply is far too low to permit the best growth of general farm crops. The application of some nitrogenous fertilizing materials is necessary on such soils. But on all the types in the area the regular addition of such fertilizers is necessary in order to permit the maintenance of the supply of the element in sufficient amounts to give the best crop growth. The thorough utilization of all the farm manure produced on the farm will aid materially in building up and maintaining the supply of nitrogen in the land. The turning under of legumes as green manures, if these crops are well inoculated as they should be, is the cheapest and best means of increasing the amount of nitrogen in the land and it is the best supplement to the use of farm manure. The proper use of all crop residues will also help materially in keeping up the nitrogen in the soil.

The supply of total organic carbon in the soils of the area varies considerably in the different soil types present, ranging from 25,252 pounds per acre in the Lindley silt loam up to 53,503 pounds per acre in the colluvial phase of the Wabash silt loam. These are the same soils which showed the lowest and highest contents of nitrogen respectively. Thus there is a definite indication of the relationship between nitrogen and organic matter which is usually observed. In general it seems that soils which are high in nitrogen are high in organic matter and vice versa. Thus land which is deficient in organic matter is apt also to be in need of nitrogen and the addition of organic materials supplying both constituents is particularly desirable.

There is little indication of any relation between the organic matter content and the soil group, except that the terrace and bottomland soils are richer on the average than the upland types, which is what might be expected. The differences are hardly of significance, however, as some of the types within groups are much higher than the average figures, while others are considerably lower. There is more difference within groups than there is between groups.

The relationship between the soil series and the content of organic carbon is similar to that noted in the case of nitrogen. Those characteristics which determine the soil series are reflected in the organic matter content. Thus the Shelby silt loam is richer in organic matter than the Lindley silt loam just as it was in nitrogen. The Grundy and Edina soils are the richest of the loess types, the Weller silt loam coming third and being followed by the Putnam, Clinton and Marion, the Clinton being the lowest of all, owing largely to its timber origin and its rough topography. The Bremer and Chariton soils are richer than the Calhoun silt loam and the colluvial phase of the Wabash silt loam is higher than the typical silt loam. These are all due to the series characteristics of color, topography, origin and subsoil condition and hence the series of the soil will show roughly something of its content of organic matter.

The textural effects of the soil upon the organic matter content is shown only in the case of the Bremer silty clay loam which is higher than the silt loam of the same series. This is the only comparison possible among the soils of this county. In general it has been found in all other comparisons in individual counties that the finer the texture of the soils the higher is the content of organic matter. Coarse-textured types like the sands are the lowest in organic matter and fine-textured soils like the clays are the highest within the same series.

The supply of organic matter is too low for the best results with crops on many of the soils in this county and applications of materials supplying organic matter are necessary in many cases. This is especially true on the lighter-colored poorer soils, but even on those which are darker in color and apparently better supplied there is need for the regular addition of fertilizing materials supplying organic matter if the content is to be maintained. Such additions often bring about large increases in crop yields evidencing the value of the treatment. The use of farm manure, crop residues and leguminous green manures is necessary to the increasing and maintaining of the fertility of the soils of this county. These materials will supply organic matter and also return some of the plant foods removed by the crops grown — hence they have a double value. In the case of the legumes as green manures, if they are inoculated they may also add some of the nitrogen from the air and thus enrich the land in that element. Hence green manuring is a particularly important and desirable practice.

The soils of the county are all acid in reaction and there is no content of inorganic carbon in them. The limestone requirements of the various types, as determined by the Truog qualitative test, are suggestive only and should not be accepted as indicating the exact needs of the soils under individual farm conditions. The lime needs of soils vary widely from field to field and the only way to determine the proper amount of lime to use on any particular area is to test a sample of that particular soil. Tests should always be made on the soils which are to be treated before any addition is made. The figures given in the table do, however, indicate that the limestone requirements of the soils of the area are high and considerable lime is necessary to meet the needs of the soils. By making tests in each case it is possible to put on the right amount and obtain the best results. Such tests should be made on the land regularly in the rotation, preferably once in each rotation preceding the legume crop to be sure that the soil is in the best condition for the growth of the legume.

The Subsurface Soils and Subsoils

The results of the analyses of the subsurface soils and subsoils are given in tables 5 and 6. They are calculated on the basis of 4 million pounds of subsurface soil and 6 million pounds of subsoil. They will not be discussed in detail as they do not as a whole change the conclusions drawn from the results of the analyses of the surface samples. Unless there is a strikingly large content of some plant nutrient in the subsoil, or a large deficiency, the amount present in the lower soil layers is of little significance in changing the conclusions as to the needs of the soil as deduced from the analyses of the surface layers. The analyses made on the subsurface soils and subsoils in this county do not show any important changes from the results on the surface soils, and merely serve to confirm the conclusions drawn from the surface soil results.

GREENHOUSE EXPERIMENTS

Greenhouse experiments were carried out on two soils from Monroe County — the Grundy silt loam and the Clinton silt loam — in order to obtain some evidence of the needs of these soils and of the value of certain fertilizing materials.

The fertilizing treatments tested included manure, limestone, superphosphate and muriate of potash. Manure was added at the rate of 10 tons per acre, limestone in sufficient amounts to neutralize the acidity of the soil, superphosphate at the rate of 250 pounds per acre and muriate of potash at the rate of

TABLE 5. PLANT FOOD IN MONROE COUNTY, IOWA, SOILS
Pounds per acre of 4 million pounds of subsurface soil (6⅔″–20″)

Soil no.	Soil type	Total phosphorus	Total nitrogen	Total organic carbon	Total inorganic carbon	Limestone requirement
	DRIFT SOILS					
93	Shelby silt loam	1,131	2,240	32,996	....	7,000
65	Lindley silt loam	942	1,600	22,470	....	8,000
	LOESS SOILS					
64	Grundy silt loam	1,650	4,347	65,593	....	6,000
261	Weller silt loam	1,560	3,600	45,050	....	7,000
80	Clinton silt loam	1,427	2,080	23,834	....	8,000
66	Putnam silt loam	1,293	1,920	34,360	....	7,000
211	Edina silt loam	1,320	3,040	46,249	....	7,000
67	Marion silt loam	1,372	1,520	18,543	....	8,000
	TERRACE SOILS					
88	Bremer silt loam	2,936	5,280	73,792	....	5,000
105	Chariton silt loam	2,100	3,840	55,848	....	7,000
42	Calhoun silt loam	1,130	1,360	21,434	....	7,000
43	Bremer silty clay loam	1,912	3,600	55,085	....	7,000
	SWAMP AND BOTTOMLAND SOILS					
26	Wabash silt loam	2,612	6,080	73,465	....	2,000
26a	Wabash silt loam (colluvial phase)	2,100	3,240	100,844	....	7,000
	RESIDUAL SOIL					
183	Dubuque silt loam	1,912	2,480	28,415	....	8,000

TABLE 6. PLANT FOOD IN MONROE COUNTY, IOWA, SOILS
Pounds per acre of 6 million pounds of subsoil (20″–40″)

Soil no.	Soil type	Total phosphorus	Total nitrogen	Total organic carbon	Total inorganic carbon	Limestone requirement
	DRIFT SOILS					
93	Shelby silt loam	1,212	1,320	36,569	....	6,000
65	Lindley silt loam	1,373	960	21,025	....	8,000
	LOESS SOILS					
64	Grundy silt loam	1,952	4,000	62,475	....	6,000
261	Weller silt loam	2,525	2,340	32,070	....	7,000
80	Clinton silt loam	2,625	2,280	24,215	....	8,000
66	Putnam silt loam	2,343	3,600	52,194	....	8,000
211	Edina silt loam	1,737	3,240	46,468	....	7,000
67	Marion silt loam	3,192	2,160	32,724	....	8,000
	TERRACE SOILS					
88	Bremer silt loam	3,999	5,160	87,045	....	6,000
105	Chariton silt loam	2,667	3,480	54,894	....	7,000
42	Calhoun silt loam	2,019	2,640	37,714	....	8,000
43	Bremer silty clay loam	2,745	4,200	77,228	....	8,000
	SWAMP AND BOTTOMLAND SOILS					
26	Wabash silt loam	3,111	5,520	76,246	....	2,000
26a	Wabash silt loam (colluvial phase)	2,625	6,000	111,261	....	7,000
	RESIDUAL SOIL					
183	Dubuque silt loam	3,837	3,000	19,470	....	8,000

50 pounds per acre. Wheat and clover were grown in the pots, the clover being seeded when the wheat was up. While the experiments were of course carried out under the artificial conditions of the greenhouse and some variations were unavoidable, in general the data may be considered to indicate fairly well what may happen under field conditions.

Results on the Grundy Silt Loam

The results obtained in the experiment on the Grundy silt loam are shown in table 7.

Manure brought about an increase in the yield of wheat and increased the clover enormously. Limestone with the manure had a large effect on the wheat and a very large influence on the clover. Superphosphate alone had a larger effect on the wheat than did the manure alone but it had a smaller effect on the clover. Manure and superphosphate had a greater effect on the clover than did the superphosphate alone or the manure alone but it had a lesser effect on the wheat than either of the treatments alone. It seems that this result is probably abnormal. The superphosphate and lime had a much greater effect on the wheat than did the manure and lime or either of the treatments alone and it had about the same effect on the clover as did the manure and superphosphate. The manure, limestone and superphosphate had no greater effect on the wheat than did the superphosphate and limestone but it did show a greater effect on the clover. The muriate of potash applied with the manure, lime and superphosphate brought about an increase in the clover but had no effect on the wheat.

TABLE 7. GREENHOUSE EXPERIMENT, GRUNDY SILT LOAM, MONROE COUNTY

Pot no.	Treatment	Weight of wheat grain in grams	Weight of clover in grams
1	Check	2.69	8.6
2	Manure	3.89	27.6
3	Manure+limestone	5.69	52.2
4	Superphosphate	5.70	24.9
5	Manure+superphosphate	3.43	35.5
6	Limestone+superphosphate	6.92	35.2
7	Manure+limestone+superphosphate	6.55	43.9
8	Manure+limestone+superphosphate+muriate of potash	6.25	58.9

Fig. 3. Greenhouse experiment. Wheat on Grundy silt loam.

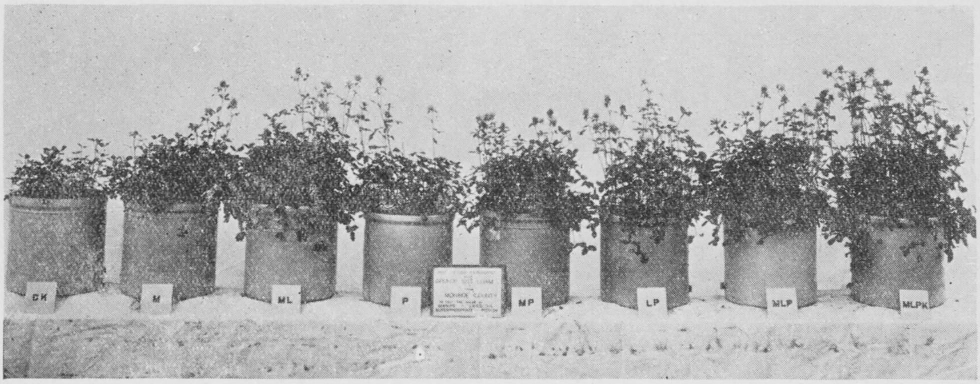


Fig. 4. Greenhouse experiment. Clover on Grundy silt loam.

Results on the Clinton Silt Loam

The data from the experiment on the Clinton silt loam are given in table 8. Manure brought about a very large increase in the yield of wheat and also

TABLE 8. GREENHOUSE EXPERIMENT, CLINTON SILT LOAM, MONROE COUNTY

Pot no.	Treatment	Weight of wheat grain in grams	Weight of clover in grams
1	Check	3.71	9.0
2	Manure	8.35	22.8
3	Manure+limestone	9.86	36.3
4	Superphosphate	8.70	25.2
5	Manure+superphosphate	11.45	22.4
6	Limestone+superphosphate	9.48	25.9
7	Manure+limestone+superphosphate	10.60	43.9
8	Manure+limestone+superphosphate+muriate of potash	11.72	58.6

in the clover. Limestone with the manure gave a further increase in both crops, the gain being large in the case of the clover. Superphosphate alone had about the same effect as the manure alone on the wheat but a slightly larger effect on

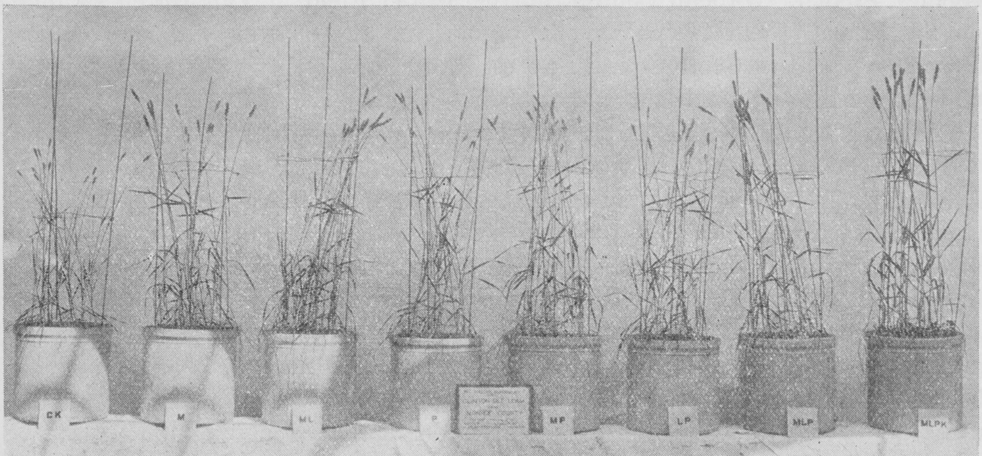


Fig. 5. Greenhouse experiment. Wheat on Clinton silt loam.

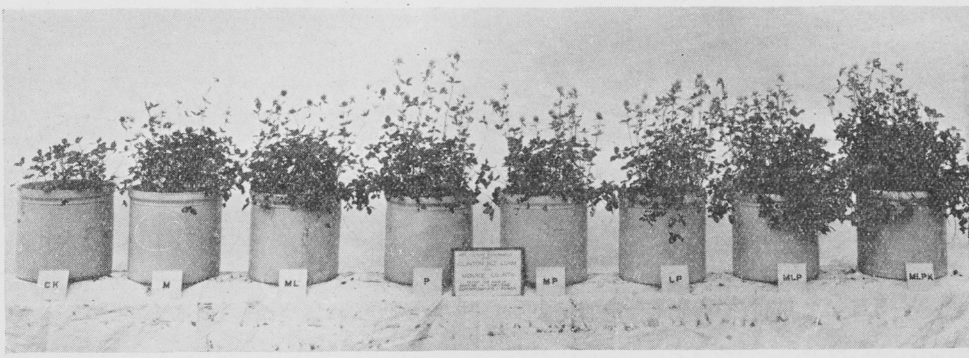


Fig. 6. Greenhouse experiment. Clover on Clinton silt loam.

the clover. It had a lesser effect than the manure and lime. Manure and superphosphate together had a much larger effect on the wheat than did either material alone, but there was no gain in the case of the clover. Limestone with superphosphate showed a gain over the superphosphate alone in the case of the wheat and had a slight effect on the clover. Manure with lime and superphosphate gave about the same effect as the manure and superphosphate, being slightly less in fact, but it had a very much larger influence on the clover. Muriate of potash with the manure, lime and superphosphate increased the yields of both crops, showing a large effect on the clover, and a slight influence on the wheat.

FIELD EXPERIMENTS

No field experiments are located in Monroe County, but tests are under way in a number of adjoining counties on the same soil types which occur in extensive areas in this county. The data from some of these fields will be given here as they indicate the effects of the same fertilizer treatments on the soils of this county and suggest what may be desirable treatments on individual farms. Results of tests which are given include those obtained on the Grundy silt loam on the Mt. Pleasant Field, Series 100 and Series 200 in Henry County, on the Agency Field in Wapello County, on the Milton Field in Van Buren County, on the Farson Field II in Wapello County, on the Clinton silt loam on the Princeton Field in Scott County, on the Lockridge Field in Jefferson County and on the Keosauqua Field in Van Buren County.

All these field experiments are carried out on land which is quite representative of the soil type to be studied. The fields include 9 or 13 plots, 155 feet 7 inches by 27 feet, each plot being one-tenth of an acre in size. They are permanently located by the installation of corner stakes, and the utmost care is taken in the applying of the fertilizing materials and in the harvesting of the crops in order that the results may be satisfactorily accurate.

The various tests are conducted under what are known as the livestock or the grain systems of farming. Under the livestock system manure is applied as the basic treatment, while under the grain system, crop residues are thoroughly utilized. The fertilizing materials tested under both systems include limestone, rock phosphate, superphosphate, muriate of potash and a complete commercial fertilizer. The manure is applied at the rate of 8 tons per acre once in a 4-year rotation. The crop residue treatment consists of plowing under the corn stalks which have been cut with a disc or stalk cutter in the spring after having been winter pastured. Sometimes the second crop of clover is plowed under but usually it is used for seed, hay or pasture and only the residues are plowed down. Limestone is applied in amounts sufficient to neutralize the acidity of the soil. Rock phosphate is applied at the rate of 500 pounds of the finely ground material per acre once in 4 years. Until 1923 this material was applied at the rate of 1 ton per acre once in 4 years and from 1923 to 1932 at the rate of 1,000 pounds per acre once in the 4-year rotation. Superphosphate is added at the rate of 120 pounds of the 20 percent material per acre, 3 times in the 4-year rotation, not being applied to the clover. Until 1923, 16 percent superphosphate was used at the rate of 200 pounds per acre annually. The 20 percent material was first used in 1929. Until 1923 the old standard 2-8-2 complete commercial fertilizer was employed, being added at the rate of 300 pounds per acre annually. From 1923 to 1929 a standard 2-12-2 brand was used, being applied at the rate of 200 pounds per acre annually. This supplied the same amount of phosphorus as that added in the superphosphate. Since 1929 a 2-12-6 fertilizer has been used on the Grundy silt loam and a 4-16-4 on the Clinton silt loam. Muriate of potash is applied at the rate of 50 pounds per acre 3 years out of 4 in the 4-year rotation. Until 1934 it was applied at the rate of 25 pounds per acre 3 years in the rotation.

The Mt. Pleasant Field

The results obtained in the field test on the Grundy silt loam on the Mt. Pleasant Field, Series 100 in Henry County, are given in table 9. Manure has given large effects on the crop yields on this soil in almost all seasons. The beneficial effects of the treatment appeared particularly on the corn in 1920 and 1928, on the oats in 1926 and 1933 and on the clover in 1927 and 1934. Some increases were obtained on these crops in most other seasons. The addition of limestone with the manure gave crop increases which were large in some seasons. The corn in 1917, 1920, 1929 and 1932 showed very large effects from the limestone. The oats in 1922 and the clover in 1927 and 1934 were also largely increased. Some increases were shown in practically all seasons from the use of the lime.

Rock phosphate with the manure and limestone gave increases in crops which were quite definite in all cases and in some instances brought about gains which were very large. This was true for the clover in 1919, 1927 and 1934, the corn in 1925, 1928 and 1929 and the oats in 1926 and 1933. Superphosphate with manure and limestone likewise showed a large effect on the crop growth in all seasons and, in all but three cases, gave a larger effect than that brought about by the rock phosphate. A greater influence was shown on the clover in 1919 and 1927, on the corn in 1925, and on the oats in 1926, 1930 and 1934. In the other seasons the differences were not so large, but they were quite definite. Complete commercial fertilizer with manure and limestone showed effects very similar to those brought about by the superphosphate. In some instances the increases were somewhat larger while in other seasons the effects were less definite than those from superphosphate. On the average it seems that just as large effects may be brought about by superphosphate.

Crop residues showed no large effects on yields. In a few instances small gains were noted. Limestone with crop residues brought about distinct increases in yields. This was true of the oats in 1919, 1930 and 1933, the corn in 1920 and 1928 and the clover in 1927 and 1934. In other seasons beneficial effects were shown but not so definitely. Rock phosphate and superphosphate with residues and limestone gave crop increases in practically all cases. In general superphosphate seemed to be somewhat more effective than rock phosphate. The differences were not large in some seasons but with the clover in 1919, 1927 and 1934 and the oats in 1926 the superphosphate proved much superior to the rock phosphate. In one or two instances the rock phosphate had more effect than superphosphate. Complete commercial fertilizer in general produced about the same effect as superphosphate.

The results obtained in the experiment on the same soil type — the Grundy silt loam — on the Mt. Pleasant Field, Series 200 in Henry County, are given in table 10. Beneficial effects from the application of manure are evident in increased crop yields obtained in all but three seasons. Large increases were noted on the oats in 1921, on the clover in 1926 and 1930 and on the corn in 1927. Limestone with manure increased the crops in nearly all seasons. Considerable increases were obtained, for example, with the corn in 1920, 1924, 1927, 1928, 1931, 1932 and 1933 and with the clover in 1926 and 1930.

Rock phosphate with manure and limestone brought about increases in some seasons, showing up particularly well on the oats in 1921, 1925 and 1929, on the clover in 1922, 1926 and 1930 and on the corn in 1927, 1928 and 1933. Superphosphate with manure and limestone showed a greater effect than rock phosphate in some seasons, especially on the corn in 1920, on the oats in 1921 and 1929 and on the clover in 1926 and 1930. In other seasons the effects were less or similar to those brought about by the rock phosphate. Complete commercial fertilizer with manure and limestone had larger effects than superphosphate in one or two cases, notably on the corn in 1920 and on the clover in 1922. In most of the other seasons the effects were less evident than those brought about by the superphosphate.

Crop residues had little effect on the crops grown in the different seasons. Limestone with the residues brought about beneficial effects on most crops. The clover in 1922, 1926 and 1930 was definitely increased. The corn was increased in 1923, 1927, 1928, 1931, 1932 and 1933. In the other seasons the effects were small and not so definite.

Rock phosphate with the residues and limestone proved valuable in practically all cases. Some crop increases were not large and in one or two instances no increases were obtained. Superphosphate with the residues and limestone showed larger effects than the rock phosphate in practically all seasons. The influence was much greater on the corn in 1920, on the oats in 1925 and on the clover in 1926. In the other seasons the effects were about the same or slightly less than those caused by the rock phosphate. Complete commercial fertilizer with residues and limestone showed a larger effect than superphosphate in one or two cases but in general the differences were small and there was no evidence of superiority of the complete commercial fertilizer over the superphosphate.

TABLE 9. FIELD EXPERIMENT, GRUNDY SILT LOAM, HENRY COUNTY, MT. PLEASANT FIELD,* SERIES 100

Plot no.	Treatment	1916 corn bu. per A. (1)	1917 corn bu. per A. (2)	1918 oats bu. per A.	1919 clover tons per acre			1920 corn bu. per A. (3)	1921 corn bu. per A. (4)	1922 oats bu. per A. (5)	1923 soybeans (6)	1924 corn bu. per A.	1925 corn bu. per A.	1926 oats bu. per A. (7)	1927 clover tons per A. (8)	1928 corn bu. per A. (9)	1929 corn bu. per A. (10)	1930 oats bu. per A.	1931 soybeans tons per A. (11)	1932 corn bu. per A.	1933 oats bu. per A. (12)	1934 clover tons per A.	1935 (13)
					First crop	Second crop	Total crop																
1	Check	27.4	36.0	72.3	2.22	1.65	3.87	34.5	54.3	35.9	...	50.7	41.2	20.5	0.05	25.0	13.6	37.8	2.26	64.4	21.1	0.38	...
2	Manure	22.2	37.5	75.1	2.29	1.50	3.79	57.0	56.7	39.8	...	54.0	35.9	30.4	0.40	45.0	18.1	30.3	2.09	67.3	31.4	0.55	...
3	Manure+limestone	15.3	55.2	74.8	2.34	1.65	3.99	76.6	59.5	62.1	...	58.7	40.6	35.9	0.64	66.3	42.5	37.9	2.09	79.6	33.8	0.92	...
4	Manure+limestone+rock phosphate	40.4	66.0	76.5	2.78	2.15	4.93	81.8	67.5	63.3	...	66.0	50.6	47.3	1.46	78.3	55.4	43.7	2.96	74.7	58.4	0.99	...
5	Manure+limestone+superphosphate	55.9	73.6	85.1	3.72	2.75	6.47	77.7	72.8	70.1	...	60.7	64.4	66.4	1.56	77.3	54.3	59.4	2.96	78.7	70.1	1.00	...
6	Manure+limestone+complete commercial fertilizer	54.1	76.8	80.8	3.68	3.25	6.93	67.5	64.9	70.6	...	62.0	63.7	70.9	1.31	84.3	61.8	60.1	3.14	73.4	60.1	0.95	...
7	Check	47.9	60.1	76.5	2.20	2.20	4.40	65.6	60.7	56.1	...	54.0	54.1	40.2	0.51	52.7	27.8	35.9	2.26	58.2	22.1	0.52	...
8	Crop residues	41.7	50.8	81.3	2.30	...	...	67.5	65.7	54.5	...	52.0	55.0	40.6	0.89	58.3	26.8	39.7	2.53	65.2	34.1	0.56	...
9	Crop residues+limestone	30.3	47.1	93.2	2.22	...	...	80.6	66.1	49.0	...	55.3	56.2	39.9	0.67	63.0	31.8	49.9	2.79	65.1	43.9	0.95	...
10	Crop residues+limestone+rock phosphate	30.4	52.7	96.4	2.85	...	...	90.0	65.0	57.9	...	57.7	56.5	38.8	1.09	60.7	36.4	56.8	2.61	65.8	44.8	1.12	...
11	Crop residues+limestone+superphosphate	30.6	54.7	99.9	3.21	...	...	75.5	66.9	54.8	...	59.3	57.2	48.4	1.43	63.3	39.3	59.4	2.44	66.2	44.8	1.22	...
12	Crop residues+limestone+complete commercial fertilizer	27.0	52.8	93.6	3.15	...	...	51.2	67.1	61.9	...	59.7	58.1	47.3	1.28	72.7	49.3	51.0	2.44	70.2	51.5	1.08	...
13	Check	21.1	48.3	72.3	2.18	2.00	4.18	45.0	59.1	42.3	...	50.0	52.8	30.6	0.35	53.6	29.1	34.8	2.18	66.6	32.9	0.66	...

(1) Season wet, corn weedy but good quality.
(2) Short season, early frost.
(3) Cattle trampled plot 1.
(4) Corn not uniform.
(5) Three tons limestone applied, oats thin and down. Smartweed bad in plots 11 and 12.
(6) No record on account of weeds.
(7) Low yield due to very dry season and considerable rust.
(8) Very poor stand on check plots.
(9) Poor yield on plots 1 and 2 due to low, wet area.
(10) Poor yield on plots 1 and 2 due to low, wet area.
(11) Clover killed out; soybeans substituted.
(12) Wet spring, followed by hot dry weather in June and July, damaged oats.
(13) Field discontinued.

*The Mt. Pleasant Field, Series 100, was established in 1914 on the State Hospital Farm at Mt. Pleasant in Henry County. It is located in the SE ¼ of the SW ¼ of Section 14, T. 71 N., R. 6 W., Center Twp.

TABLE 10. FIELD EXPERIMENT, GRUNDY SILT LOAM, HENRY COUNTY
MT. PLEASANT FIELD,* SERIES 200**

Plot no.	Treatment	1919 corn bu. per A.	1920 corn bu. per A.	1921 oats bu. per A. (1)	1922 clover tons per A. (2)	1923 corn bu. per A.	1924 corn bu. per A.	1925 oats bu. per A.	1926 clover tons per A. (3)	1927 corn bu. per A.	1928 corn bu. per A. (4)	1929 oats bu. per A. (5)	1930 clover tons per A.	1931 corn bu. per A. (6)	1932 corn bu. per A. (7)	1933 corn bu. per A. (8)
1	Check	55.7	48.1	36.9	1.6	61.3	49.3	50.9	0.10	33.8	47.3	14.3	0.54	51.4	65.3	51.7
2	Manure	66.3	51.2	46.9	1.9	77.3	58.0	55.0	0.60	44.4	42.3	22.1	1.23	55.5	74.9	38.4
3	Manure+limestone	74.1	69.8	35.3	2.1	85.0	72.7	50.9	1.05	60.0	54.7	24.0	1.43	65.2	88.9	50.1
4	Manure+limestone +rock phosphate	78.6	66.4	42.6	2.4	84.5	70.4	65.9	1.31	76.9	77.0	46.8	1.97	67.2	86.9	76.8
5	Manure+limestone +superphosphate	75.3	77.2	48.9	2.4	77.6	73.3	64.8	1.43	76.6	77.3	52.3	2.16	67.2	88.1	77.1
6	Manure+limestone +complete commercial fertilizer	66.5	81.2	46.5	2.7	80.0	65.7	60.4	1.15	65.0	76.3	40.5	2.15	59.3	88.9	71.8
7	Check	50.6	64.0	33.7	2.1	58.3	44.3	47.1	0.52	40.6	47.3	32.9	0.47	50.1	69.8	51.5
8	Crop residues	65.3	75.5	43.1	2.3	64.6	35.3	47.6	0.52	47.5	48.0	24.7	0.49	47.7	71.4	52.7
9	Crop residues+ limestone	71.0	76.3	40.0	2.6	73.3	34.7	56.1	0.76	67.5	69.7	30.8	1.65	51.3	76.1	59.8
10	Crop residues+ limestone+rock phosphate	75.1	75.1	43.8	2.5	69.0	38.0	52.5	0.86	59.7	68.0	33.2	1.94	57.1	73.1	61.1
11	Crop residues+ limestone+superphosphate	81.1	85.1	43.5	2.5	68.0	40.7	63.2	0.96	53.8	64.0	34.7	1.98	57.4	71.9	61.3
12	Crop residues+ limestone+complete commercial fertilizer	78.5	90.1	42.2	2.6	74.3	41.3	60.4	0.99	47.2	70.0	21.2	1.68	58.3	82.4	60.0
13	Check	65.8	64.1	31.1	1.7	60.3	39.3	43.8	0.39	33.1	47.7	21.0	0.48	53.3	71.1	44.3

(1) Three tons limestone applied, oats lodged in spots.
(2) Two crops on all but crop residue plots. Yields represent only first cutting.
(3) Plots 7 to 13 were partly burned off in April. Check plots badly infested with weeds.
(4) Low yield in plot 2 due to wet spot in field.
(5) Wet season cut oat yield.
(6) Hot, dry season.
(7) Corn drilled across plots. Difficult to harvest uniform stand.
(8) Plots 2 and 3 poorly drained.
*The Mt. Pleasant Field, Series 200, was established in 1914 on the State Hospital farm at Mt. Pleasant in Henry County. The series is located in the SE ¼ of the SW ¼ of Section 14, T 71 N, R 6 W, Center Twp.
**Yields for 1915–1916–1917–1918 not included due to irregularities; no results in 1934 due to chinch bugs and drouth; field discontinued in 1935.

The Agency Field

The data obtained on the Grundy silt loam on the Agency Field in Wapello County are given in table 11. Manure proved valuable on this soil in practically all seasons. The largest crop increases were shown on the oats in 1919, 1925 and 1930, on the hay in 1921, 1922 and 1927, on the corn in 1928, 1929 and 1933 and on the wheat in 1931. Limestone with manure brought about increases in practically all cases. Beneficial effects of limestone were especially evident on the hay crops but increases were also shown in some cases on the corn and oats.

Rock phosphate with manure and limestone increased crop yields in every season, in some cases large effects being noted. The hay crops were particularly benefited by the rock phosphate and considerable increases were obtained on the oats in 1919 and 1930, on the corn in 1923 and 1929 and on the wheat in 1926

TABLE 11. FIELD EXPERIMENT, GRUNDY SILT LOAM, WAPELLO COUNTY, AGENCY FIELD,* SERIES I

Plot no.	Treatment	1918 corn bu. per A. (1)	1919 oats bu. per A.	1920 winter wheat bu. per A. (2)	1921 clover and tim. tons per A. (3)	1922 timothy tons per A. (4)	1923 corn bu. per A.	1924 corn bu. per A.	1925 oats bu. per A.	1926 winter wheat bu. per A. (5)	1927 clover tons per A. (6)	1928 corn bu. per A.	1929 corn bu. per A.	1930 oats bu. per A. (7)	1931 winter wheat bu. per A.	1932 red clover tons per A.	1933 corn bu. per A.	1934 corn bu. per A. (8)	1935 oats bu. per A.
1	Check	63.5	44.9	22.7	1.92	2.00	72.7	46.4	66.2	21.7	1.28	83.3	66.8	52.3	20.4	2.24	54.5	...	48.8
2	Manure	64.5	62.2	31.5	2.09	2.20	71.8	51.9	70.8	19.0	1.96	89.4	72.7	63.7	28.3	2.05	62.1	...	45.4
3	Manure+limestone	66.8	58.3	36.7	2.20	2.25	79.2	52.2	73.8	21.8	2.28	100.5	72.6	64.8	26.4	2.31	71.8	...	54.5
4	Manure+limestone+rock phosphate	68.8	63.6	38.7	2.52	2.30	86.8	54.0	80.6	35.3	2.14	105.4	83.4	80.8	39.3	2.35	75.8	...	54.5
5	Manure+limestone+superphosphate	70.0	66.6	40.0	2.39	2.80	85.4	60.2	77.9	38.9	2.05	97.8	78.2	83.3	38.2	2.38	72.9	...	63.5
6	Manure+limestone+complete commercial fertilizer	66.0	65.6	34.7	2.52	2.50	83.0	55.4	77.3	30.7	2.47	101.0	85.1	68.6	43.6	2.50	77.6	...	51.0
7	Check	59.3	54.5	...	1.82	2.30	69.7	43.3	67.8	14.7	1.29	74.4	63.3	50.6	21.0	1.83	58.8	...	52.6
8	Crop residues	58.5	49.0	31.4	1.81	2.20	66.3	43.7	66.4	18.7	1.28	76.4	67.6	56.6	21.2	1.91	57.8	...	31.8
9	Crop residues+limestone	61.3	59.5	43.8	2.02	2.40	71.3	50.7	72.1	18.6	1.69	83.5	73.2	59.5	28.3	2.14	65.1	...	48.8
10	Crop residues+limestone+rock phosphate	61.8	61.2	36.4	2.33	2.65	73.1	54.9	75.9	26.0	2.14	96.6	77.5	70.8	30.9	2.32	67.5	...	57.9
11	Crop residues+limestone+superphosphate	63.5	61.2	36.3	2.19	2.75	80.7	55.5	74.6	...	2.26	93.4	69.0	72.4	36.0	2.29	68.6	...	54.5
12	Crop residues+limestone+complete commercial fertilizer	62.5	63.6	35.6	2.17	2.65	70.4	54.4	78.4	...	2.14	93.6	77.3	85.5	38.5	2.35	70.7	...	60.1
13	Check	52.5	52.0	22.8	1.56	2.40	63.9	42.7	58.5	...	0.91	67.0	56.5	55.5	28.7	1.36	60.1	...	49.9

(1) Corn damaged slightly by hail in July and dry weather in August.
(2) Sample No. 7 lost in transit; wheat badly down. Light dressing of manure to all plots by mistake in winter of 1920. Lime applied in November.
(3) Pastured after first crop.
(4) Pastured after first crop.
(5) Wet weather prevented seeding of plots 11, 12 and 13.
(6) Mostly timothy.
(7) Oats later in maturity on plot 6, damaged by hot winds.
(8) Corn poor due to drouth, cut for fodder.
*The Agency Field was laid out in fall of 1917 on the Johnson Brothers farm, northeast of Agency, in Wapello County. The series is in the northeastern corner of NW¼ of the SE ¼ of Section 30, R. 12 W., T. 72 N.

and 1931. Superphosphate with manure and limestone showed larger effects than rock phosphate in most seasons. There were no strikingly large differences except in the case of the hay crop in 1922 and the oats in 1935. There were some gains for the superphosphate in some other seasons but in 1921, 1923, 1928, 1929 and 1933 rock phosphate gave somewhat larger effects than superphosphate on the corn and in 1925 on the oats. Complete commercial fertilizer with manure and limestone generally showed somewhat smaller effects than superphosphate. Only on the hay crop in 1921, the clover and timothy in 1927, the clover in 1932, the corn in 1928 and 1929 and the wheat in 1931 was there any greater effect from the complete fertilizer.

Crop residues showed little effect. Limestone with the residues increased the crops in practically every season. Only in the instance of wheat in 1926 was there no increase from the use of limestone. In some cases and on certain of the crops the beneficial effects were quite definite. This was particularly true of the hay crop in 1921 and 1922, of the clover in 1927 and 1932, of the corn in 1928 and 1929 and of the wheat in 1931.

Rock phosphate with the residues and limestone brought about increases in crop yields in practically all seasons. In some instances the increases were quite distinct, as on the hay crop in 1921, 1922 and 1927, on the wheat in 1926, on the corn in 1928 and 1929 and on the oats in 1930 and 1935. Superphosphate with residues and limestone showed larger effects, however, than rock phosphate on the clover in 1921, on the oats in 1925 and 1935 and on the corn in 1928 and 1929 and practically the same effect on the corn in 1923 and on the wheat in 1920. Complete commercial fertilizer with the residues and limestone gave increases similar to those brought about by superphosphate. Only in one or two cases was there any great difference. On the corn in 1923 complete fertilizer had no effect.

The Milton Field

The results obtained in the field experiment on the Grundy silt loam on the Milton Field in Van Buren County are given in table 12. Manure had a beneficial effect on the crops grown in practically all seasons. The largest influence appeared on the corn in 1924, on the oats in 1925, on the soybeans in 1927, on the hay in 1929 and 1932 and on the wheat crops. Limestone with the manure had a beneficial effect on the crops in some seasons, showing up especially on the clover in 1927, and on the corn in 1933 and 1935. Some increases were found in other seasons also.

Rock phosphate with the manure and limestone showed considerable effects on the crops in some cases, as on the timothy and clover in 1929, the clover in 1932 and the wheat in 1928 and 1931. Superphosphate with manure and limestone had larger effects than the rock phosphate in several cases, showing up especially well on the clover in 1932 and on the corn in 1926 and 1935. In general the differences between the effects of the two phosphates were not large. The muriate of potash with the manure, limestone and superphosphate showed some effects on the crops grown in a few cases, notably on the hay crop in 1929, on the soybeans in 1927 and on the wheat crops. There were only small effects in most instances. Complete commercial fertilizer with the manure and limestone

TABLE 12. FIELD EXPERIMENT, GRUNDY SILT LOAM, VAN BUREN COUNTY MILTON FIELD,* SERIES I

Plot no.	Treatment	1924 corn bu. per A. (1)	1925 oats bu. per A.	1926 corn bu. per A. (1)	1927 soybeans tons per A. (2)	1928 winter wheat bu. per A. (3)	1929 tim. and clover tons per A.	1930 corn bu. per A. (4)	1931 winter wheat bu. per A.	1932 red clover tons per A.	1933 corn bu. per A. (5)	1934 corn bu. per A. (6)	1935 corn bu. per A. (7)
1	Check	36.0	51.7	44.3	2.73	2.4	1.25	...	25.5	1.65	46.1	...	30.0
2	Manure	46.4	58.0	43.2	3.11	9.7	1.92	...	29.9	2.02	47.5	...	27.2
3	Manure+limestone	44.8	55.0	46.9	3.17	8.5	1.69	...	35.5	2.17	54.7	...	36.2
4	Manure+limestone+rock phosphate	48.8	56.9	50.4	3.11	18.8	2.33	...	41.7	2.43	58.6	...	35.5
5	Check	33.2	55.0	41.9	2.62	2.4	1.27	...	27.2	1.86	40.7	...	24.0
6	Manure+limestone+superphosphate	50.6	55.5	57.9	3.00	20.6	2.25	...	37.9	2.55	59.5	...	41.9
7	Manure+limestone+superphosphate+muriate of potash	55.4	56.9	57.9	3.27	24.2	2.91	...	44.3	2.48	58.7	...	43.4
8	Manure+limestone+complete commercial fertilizer	56.0	58.0	59.5	3.49	17.5	2.01	...	41.4	2.39	61.8	...	41.0
9	Check	37.4	45.7	38.1	2.51	1.8	1.16	...	28.0	1.85	44.1	...	28.2

(1) Considerable damage by wireworms.
(2) Poor stand due to damage by wireworms.
(3) Winter-killing bad on unfertilized plots.
(4) Corn fired badly, very few ears formed; no harvest.
(5) Some chinch bug damage.
(6) Chinch bugs and drouth; corn cut for fodder.
(7) Cold, wet spring and early frosts in fall; some soft corn.
*The Milton Field was located in 1924 on the farm of Frank Holland near Milton in Van Buren County. The series is located in the SW ¼ of the SW ¼ of Section 17, R. 11 W., T. 68 N.

had somewhat greater effects than the superphosphate in some cases, as on the corn in 1924, the oats in 1925, the soybeans in 1927 and the wheat in 1931. In general, however, the differences are not large enough to show any particular value for the fertilizer over superphosphate.

The Farson Field

The data from the field experiment on the Grundy silt loam on the Farson Field, Series II, in Wapello County are shown in table 13. Manure brought about increases in crop yields in most seasons, showing the greatest effects on the clover in 1926, the sweet clover in 1933, the oats in 1925, the corn in 1927, and the wheat in 1930. Limestone with the manure had beneficial effects on the crops grown in most cases. The clover in 1920 and 1926 and the sweet clover in 1933 showed the greatest effects, as would be expected. There were also beneficial effects on some of the other crops grown.

Rock phosphate with manure and limestone had a definite effect on the crops in many seasons, the largest influence appearing on the wheat in 1930, the oats in 1932 and the sweet clover in 1933. The corn crops were increased in many cases also. Superphosphate with the manure and limestone showed somewhat greater effects than the rock phosphate in some cases, as on the clover in 1920, the oats in 1922 and 1925, the wheat in 1930, the sweet clover in 1933 and the corn in 1928 and 1931. In several instances there was little difference between the effects of the two phosphates. The complete commercial fertilizer with manure and limestone had slightly greater effects than the superphosphate in

TABLE 13. FIELD EXPERIMENT, GRUNDY SILT LOAM, WAPELLO COUNTY, FARSON FIELD,* SERIES II

Plot no.	Treatment	1918 oats bu. per A.	1919 winter wheat bu. per A. (1)	1920 clover tons per A.	1921 corn bu. per A. (2)	1922 oats bu. per A. (3)	1923 corn bu. per A.	1924 corn bu. per A.	1925 oats bu. per A.	1926 clover tons per A.	1927 corn bu. per A.	1928 corn bu. per A.	1929 barley bu. per A.	1930 winter wheat bu. per A.	1931 corn bu. per A.	1932 oats bu. per A.	1933 clover tons per A.	1934 clover tons per A. (4)	1935 clover tons per A. (4)
1	Check	72.2	11.7	1.23	60.9	27.2	61.8	31.4	43.6	1.55	67.8	66.8	14.4	16.3	57.5	41.2	0.83	...	...
2	Manure	72.2	11.7	1.19	64.8	21.8	55.8	36.6	54.7	2.34	72.0	67.1	21.9	27.5	46.2	43.2	1.56	...	...
3	Manure+limestone	70.0	15.2	1.43	65.0	44.1	66.0	41.1	59.3	2.69	75.6	77.4	27.2	28.2	64.9	43.7	1.76	...	...
4	Manure+limestone+rock phosphate	72.2	16.1	1.42	63.7	49.8	65.8	43.4	59.8	2.79	81.0	79.5	27.2	38.2	66.7	53.9	2.68	...	...
5	Manure+limestone+superphosphate	70.0	14.8	1.83	65.4	55.5	66.2	47.4	74.8	2.74	78.9	83.6	29.5	43.4	73.3	52.8	3.12	...	...
6	Manure+limestone+complete commercial fertilizer	74.3	14.6	1.66	70.1	46.0	66.0	45.1	67.2	2.91	80.6	74.0	30.3	47.8	70.2	58.1	3.10	...	...
7	Check	68.0	14.6	1.22	63.9	22.6	61.2	34.6	46.5	1.60	65.4	63.9	17.4	21.6	49.1	39.7	1.22	...	...
8	Crop residues	63.7	12.2	1.50	66.9	28.0	64.0	32.0	43.3	1.53	67.8	57.6	15.1	20.3	45.8	36.8	1.56	...	...
9	Crop residues+limestone	68.0	12.7	1.46	70.0	32.1	65.8	37.4	51.2	2.46	69.8	69.1	22.6	37.0	69.0	49.4	2.93	...	...
10	Crop residues+limestone+rock phosphate	78.6	14.8	1.62	66.0	37.6	64.2	37.7	49.3	2.11	78.4	70.6	21.2	37.3	62.4	53.4	3.27	...	...
11	Crop residues+limestone+superphosphate	72.2	15.9	1.49	61.6	27.8	68.2	38.8	72.4	2.23	78.7	68.5	19.7	42.6	71.1	51.6	3.27	...	...
12	Crop residues+limestone+complete commercial fertilizer	76.5	15.0	1.51	64.3	29.4	67.0	41.1	71.3	2.09	78.5	68.7	19.7	44.6	65.8	51.4	3.24	...	...
13	Check	70.0	15.0	1.36	57.7	17.7	58.5	31.1	41.1	1.53	70.5	56.8	13.7	24.0	47.4	40.3	1.34	...	...

(1) Wheat badly scabbed.
(2) Stand very irregular.
(3) Poor stand due to poor preparation of seedbed.
(4) Field left idle due to corn-hog reduction program.
*The Farson Field was laid out in the fall of 1917 on the farm of R. E. Hinds near Farson, in Wapello County. Two series were laid out, Series II and Series IV. Series II is located in the northwest corner of the NW ¼ of Section 30, R. 12 W., T. 73 N.

several seasons, but in general the differences were not large, and in some instances the superphosphate had the larger effect.

Crop residues had little influence on the various crops grown. Limestone with the residues increased the crop yields in many cases, the greatest influence appearing on the clover in 1926 and the sweet clover in 1933, as might be expected. There were also beneficial effects on the corn and small grain crops, however, in several seasons.

Rock phosphate with the residues and limestone showed benefits on the crops in most instances, the greatest effects appearing on the clover in 1920, the sweet clover in 1933 and the corn in 1927. The effects in the other seasons were small. The superphosphate with the residues and limestone had a greater effect than rock phosphate in some cases, as on the clover in 1926, the wheat in 1930 and the oats in 1925 where there was a very large difference in favor of the superphosphate. Complete commercial fertilizer with the residues and limestone had about the same effect as the superphosphate, showing up a little better in some cases but generally having almost identical influences. No superior value for the complete fertilizer is indicated, from the practical standpoint, owing to its greater cost.

The Princeton Field

The data obtained in the field experiment on the Clinton silt loam on the Princeton Field in Scott County are shown in table 14. Manure increased the yields on this soil in nearly every season. In some cases considerable increases were obtained, as, for example, on the wheat in 1925, on the corn in 1923, 1927, 1928, 1933 and 1935 and on the clover in 1922 and 1926. Limestone with manure still further increased the yields of crops. Beneficial effects were particularly evident on the clover in 1922, 1926 and 1931 and on the corn in 1927 and 1933. Increases in the yields of wheat and oats were also obtained in most cases and in corn yields in other seasons.

Rock phosphate with manure and limestone increased the crop yields in most seasons. The gains, however, were not generally large. Superphosphate with the manure and limestone gave considerable increases in the yields in several cases. In one or two seasons, however, the effects of superphosphate were no greater than those brought about by rock phosphate. The oats in 1924, the clover in 1926 and the corn in 1932 showed the greatest effects from the superphosphate. Complete commercial fertilizer with manure and limestone gave somewhat greater effects than superphosphate in most seasons, but in other cases the beneficial influence was less and in no case was there any considerable gain from the use of complete fertilizer over that brought about by the superphosphate.

Crop residues had little effect on the various crops grown, bringing about only slight increases in some seasons. Limestone with crop residues increased the yields in most seasons. The largest beneficial effects were shown in the case of the clover in 1922, 1926 and 1931 and on the corn in 1919, 1920, 1923, 1932 and 1933.

Rock phosphate with residues and limestone increased the crop yields in most years. With the clover the increases were quite distinct. On the other crops the

TABLE 14. FIELD EXPERIMENT, CLINTON SILT LOAM, SCOTT COUNTY, PRINCETON FIELD,* SERIES I

Plot no.	Treatment	1918 winter wheat bu. per A. (1)	1919 corn bu. per A.	1920 corn bu. per A. (2)	1921 oats bu. per A.	1922 clover tons per A. (3)	1923 corn bu. per A.	1924 oats bu. per A.	1925 winter wheat bu. per A. (4)	1926 clover tons per A.	1927 corn bu. per A.	1928 corn bu. per A.	1929 oats bu. per A. (5)	1930 winter wheat bu. per A.	1931 red clover tons per A.	1932 corn bu. per A.	1933 corn bu. per A.	1934 oats bu. per A. (6)	1935 corn bu. per A.
1	Check	40.7	69.3	61.8	27.7	1.41	54.0	65.8	13.6	0.96	67.8	64.6	46.5	15.3	0.96	97.9	78.1	10.2	63.3
2	Manure	37.4	67.6	68.3	28.4	1.93	63.2	64.8	22.6	1.57	79.7	72.7	74.9	23.2	1.02	108.9	89.4	19.2	80.0
3	Manure+limestone	43.0	68.2	70.6	32.1	2.13	70.2	65.3	27.5	2.06	97.3	74.2	70.2	26.9	1.87	113.0	96.9	21.6	78.7
4	Manure+limestone+rock phosphate	47.4	67.8	73.5	31.9	2.25	72.5	63.1	32.1	2.08	96.4	76.4	71.3	27.7	1.98	113.3	96.7	25.1	82.6
5	Manure+limestone+superphosphate	45.2	64.0	70.8	35.1	2.29	73.2	75.1	31.8	2.31	86.9	79.2	69.2	30.0	1.98	117.4	96.7	26.3	78.9
6	Manure+limestone+complete commercial fertilizer	37.3	68.4	73.0	36.4	2.34	68.1	71.9	32.4	2.15	89.8	80.7	75.0	31.1	2.32	111.3	98.9	28.3	77.9
7	Check	31.7	57.0	57.5	24.4	1.60	53.0	62.2	16.9	0.73	59.7	50.3	39.7	17.3	0.87	95.9	66.2	10.2	55.8
8	Crop residues	...	52.6	58.6	29.6	1.47	55.2	66.4	15.5	0.72	57.4	52.2	44.3	17.5	0.92	94.9	73.7	8.5	63.6
9	Crop residues+limestone	31.7	62.4	67.3	29.7	2.14	61.8	65.6	23.8	1.35	78.4	66.6	60.1	24.0	1.59	103.2	87.2	23.8	69.7
10	Crop residues+limestone+rock phosphate	35.0	64.1	68.7	29.8	2.28	65.0	63.4	26.7	2.06	81.3	69.8	56.8	28.3	1.60	97.2	82.7	21.8	70.9
11	Crop residues+limestone+superphosphate	31.7	66.6	61.5	31.1	2.18	68.0	75.1	27.1	2.03	89.0	74.4	41.9	30.6	2.08	100.6	80.4	26.9	73.4
12	Crop residues+limestone+complete commercial fertilizer	36.2	65.2	69.5	30.8	...	70.1	73.5	28.3	2.25	83.8	74.5	68.1	31.2	2.25	104.7	85.8	18.7	77.8
13	Check	28.2	59.3	59.5	25.5	...	58.6	54.4	17.5	0.98	64.0	54.4	52.1	19.0	1.05	92.5	77.8	4.4	64.3

(1) Three tons limestone applied August, 1917. Yield on plot 8 an error.
(2) Plot 11 many missing hills, low yields.
(3) Yields on plots 12 and 13 lost due to error.
(4) Stand of wheat very thin due to extreme dry spring.
(5) Oats down badly on plots 3, 4, 5, 10, 11 and 12.
(6) Dry weather and chinch bugs almost prevented an oat crop.
*The Princeton Field was established in the fall of 1917 on the Kroeger Brothers farm near Princeton in Scott County. It is located in the northwest corner of the SW¼ of the NE ¼ of Section 10, T. 79 N., R. 5 E. in Princeton Twp.

increases were smaller. Superphosphate with the residues and limestone showed somewhat larger effects than rock phosphate in some seasons. This was particularly true on the oats in 1921 and 1924, on the clover in 1931 and on the corn in 1927, 1928 and 1932. In several seasons, however, there were smaller effects from superphosphate. Complete commercial fertilizer with the residues and limestone gave larger increases than did the phosphates in several cases. This was noted particularly on the clover in 1926 and 1931 and on the corn in 1932. In most years, however, there was little difference between the effects of this material and the phosphates.

The Lockridge Field

The results of the field experiment on the Clinton silt loam on the Lockridge Field in Jefferson County are given in table 15. Manure increased the crops grown in practically every season. Limestone with manure showed a beneficial effect in all cases, the greatest effects appearing on the sweet clover as would be expected. The grain crops were also benefited by the limestone.

Rock phosphate with the manure and limestone showed a large beneficial effect on the sweet clover and the flax but did not show any influence in the other seasons. Superphosphate with manure and limestone had greater effects than the rock phosphate in all cases, the greatest differences appearing in the case of the sweet clover, and the corn in 1933. Muriate of potash with the manure, limestone and superphosphate had some effects in two seasons but the increases were not large. Complete commercial fertilizer with manure and limestone had about the same effects as the superphosphate except in the case of the oats on which it showed up much better. In the other seasons the effects from the two materials were quite similar.

TABLE 15. FIELD EXPERIMENT, CLINTON SILT LOAM, JEFFERSON COUNTY LOCKRIDGE FIELD NO. II,* SERIES I

Plot no.	Treatment	1929 oats bu. per A. (1)	1930 corn bu. per A. (2)	1931 oats bu. per A.	1932 sweet clover tons per A. (3)	1933 corn bu. per A.	1934 flax bu. per A. (4)	1935 alfalfa tons per A. (5)
1	Check	61.3	39.2	38.8	...	50.0	3.2	...
2	Manure	65.9	43.1	49.6	0.13	44.2	4.1	...
3	Manure+limestone	69.2	51.0	57.0	1.84	59.7	5.7	...
4	Manure+limestone+rock phosphate	62.4	45.9	54.8	2.79	52.3	6.9	...
5	Check	51.0	32.3	46.6	...	48.1	2.6	...
6	Manure+limestone+superphosphate	69.2	51.3	60.1	3.14	77.4	7.3	...
7	Manure+limestone+superphosphate+muriate of potash	69.2	45.7	69.5	2.91	83.4	7.8	...
8	Manure+limestone+complete commercial fertilizer	69.2	43.6	71.5	2.36	77.0	6.1	...
9	Check	38.6	28.4	36.3	...	39.1	2.0	...

(1) No manure applied until 1930.
(2) Hot, dry season.
(3) Sweet clover a total failure on check plots.
(4) Some chinch bug damage, especially on check plots. Poor drainage on plot 2.
(5) Large amount of volunteer sweet clover. Most of alfalfa smothered out. Field pastured and will go back into rotation in 1936.

*The Lockridge Field No. II, Series I, was established in 1928 on the farm of Dr. Frank Fourt near Lockridge in Jefferson County. It is located in the northeast corner of the SE ¼ of the SE ¼ of Section 33, T. 72 N, R. 8 W. in Lockridge Twp.

The Keosauqua Field

The data obtained in the field experiment on the Clinton silt loam on the Keosauqua Field in Van Buren County are shown in table 16. Manure increased crop yields in every season, showing the largest effect on the clover in 1925, the clover and timothy in 1929, the oats in 1931 and the corn in 1926, 1932 and 1935. In several cases yields were low because of unfavorable seasonal conditions. Limestone with manure brought about increases in crops in most instances, the greatest influence appearing on the clover in 1925, the timothy and clover in 1929, the oats in 1924 and 1928 and on the corn in 1927, 1932 and 1935.

Rock phosphate with manure and limestone had some beneficial effect on the crops in every season. Sometimes the gains were not very large but with the clover in 1925, the corn in 1923 and 1926 and the oats in 1924 the increases were quite definite. Superphosphate with manure and limestone had a greater effect than rock phosphate on the clover in 1925 and the clover and timothy in 1929. In other seasons, however, the effects were only slightly larger or were actually smaller than those brought about by rock phosphate. Muriate of potash with manure, limestone and superphosphate had a beneficial effect on the crops in most seasons. The largest effects appeared on the clover in 1925 and on the clover and timothy in 1929. In the other seasons the gains were not strikingly large. Complete commercial fertilizer with manure and limestone had slightly larger effects than superphosphate in one or two instances but, in general, the differences between the effects of the two were not significant.

TABLE 16. FIELD EXPERIMENT, CLINTON SILT LOAM, VAN BUREN COUNTY KEOSAUQUA FIELD,* SERIES I

Plot no.	Treatment	1923 corn bu. per A.	1924 oats bu. per A. (1)	1925 clover tons per A.	1926 corn bu. per A. (2)	1927 corn bu. per A. (3)	1928 oats bu. per A.	1929 clover and tim. tons per A.	1930 corn bu. per A. (4)	1931 oats bu. per A.	1932 corn bu. per A.	1933 oats bu. per A. (5)	1934 clover tons per A. (4)	1935 corn bu. per A.
1	Check	40.0	27.8	0.87	33.3	15.7	9.1	0.46	13.0	30.7	25.4	7.4	0.05	25.8
2	Manure	50.4	36.6	1.52	58.7	25.3	18.2	0.98	22.0	50.5	46.1	15.9	0.14	44.4
3	Manure+limestone	50.4	53.3	1.87	62.7	36.7	37.4	1.84	22.5	56.1	69.5	21.1	0.58	54.0
4	Manure+limestone+rock phosphate	58.1	61.3	2.08	83.9	37.4	38.6	1.87	25.1	58.6	70.9	24.3	0.77	60.6
5	Check	57.1	22.1	1.52	54.7	31.4	21.6	0.84	24.5	46.3	46.8	19.2	0.11	36.5
6	Manure+limestone+superphosphate	60.0	61.7	2.69	75.9	37.2	37.4	2.28	24.0	56.1	68.8	23.2	0.85	61.4
7	Manure+limestone+superphosphate+muriate of potash	59.0	71.0	2.87	78.7	40.9	37.4	2.81	23.8	62.4	72.2	30.3	0.89	68.2
8	Manure+limestone+complete commercial fertilizer	59.0	36.3	2.63	78.7	38.9	35.2	1.92	22.3	57.4	67.3	28.3	0.65	58.8
9	Check	41.9	26.2	1.00	48.0	15.7	11.3	0.69	23.3	34.7	38.9	10.2	0.06	21.8

(1) Yield on plot 8 not correct; unable to account for error.
(2) Low yield on plot 1 due to poor condition of seedbed.
(3) Late backward season; poor quality corn.
(4) Hot, dry season.
(5) Wet spring followed by hot, dry weather in June and July, seriously damaged oats.
*The Keosauqua Field was established in the fall of 1922 on the farm of J. W. McIntosh, southeast of Keosauqua in Van Buren County. It is located in the SW ¼ of the NW ¼ of Section 9, T. 68 N, R. 9 W. in Henry Twp.

THE NEEDS OF MONROE COUNTY SOILS AS INDICATED BY LABORATORY, GREENHOUSE AND FIELD TESTS

The laboratory, greenhouse and field experiments which have been discussed give some indications of the needs of the soils of this county which are quite helpful in planning necessary soil treatments. It is possible also to make some general recommendations regarding the handling of the soils in the area. The treatments suggested will, of course, need to be adapted to fit the individual farm conditions, but, in general, these adaptations are merely from the standpoint of amounts of fertilizers and specific character of the treatments, rather than from the standpoint of the treatments themselves. Abnormal conditions will of course require special examination and probably treatment. Tests of individual soils and careful examination of the farm conditions are indicated as very desirable in order that the best adaptation of the suggestions made here may be effected. It may be emphasized that all the suggestions offered are based upon the practical experiences of many farmers as well as upon the experiments available. Any of the treatments recommended may be put into operation on any farm with a minimum of difficulty and with assurance of satisfactory results under anything like normal seasonal conditions.

MANURING

There is a wide variation in the content of organic matter in the soils of Monroe County, depending upon their origin, location and the treatments to which they have been subjected since they were brought under cultivation. There are types like the Marion silt loam, the Lindley silt loam, the Calhoun silt loam and the Clinton silt loam which are very light in color and strikingly deficient in organic matter and there are types like the Putnam silt loam, O'Neill fine sandy loam and areas in the Weller silt loam and Shelby silt loam which are only a little darker in color and a little better supplied with humus. The darker colored soils like the Grundy, Edina, Waukesha, Chariton and Dubuque soils are richer in organic matter while the black soils like the Bremer types on the terraces and the bottomland Wabash soils are the highest in content of humus. But many of the soils in the darker colored areas are not sufficiently supplied with organic matter to make it unnecessary to keep up the supply. In many cases it is necessary to increase it. On all the soils of the county it is essential that additions of some fertilizing material supplying organic matter be made regularly if the content is to be kept up. On the lighter colored soils additions are particularly needed now to build up the supply and make the soils more productive. The need for organic matter and the amount which should be added may be determined roughly by the color of the soil and also by the extent of erosion on the more rolling to steep soils.

The proper use of all the manure produced on the farm is the cheapest and best means of building up and maintaining the organic matter content of the soils. When the manure is carefully preserved and all is returned to the land with a minimum of losses, the livestock farmer is aided materially in keeping up the supply of organic matter in his soils. The value of farm manure in increasing crop yields is well known but it is not generally recognized that if the manure is not properly taken care of before being applied and if it is not added to the land regularly in liberal amounts, the beneficial effects are very much lessened. Nor is it thoroughly understood that manure plays a very important part in maintaining the fertility of the land. The livestock farmer has at hand a very great aid in keeping his land productive if he will put the farm manure on his soils, regularly and properly and with the least possible deterioration. The field experiments which have been discussed earlier in this report have shown the large beneficial effects of farm manure on such soil types as the Grundy silt loam and the Clinton silt loam, two of the most important soils occurring in the county. The other soils mapped would undoubtedly respond to manure in just as large or perhaps even a larger way and the benefits on crops would be even greater on the poorer and lighter colored soils. Thus by the use of farm manure there is not only an immediate effect upon the yields of crops, but there is also a very great effect upon the fertility of the land from the permanent standpoint.

The thorough utilization of all crop residues will aid materially in maintaining the organic matter content of soils. On livestock farms the residues may be used for feed or bedding and returned to the land with the manure. On the grain farm the residues are stored and allowed to decompose partially before being applied to the land, or they may be applied directly in some cases. All crop residues should be returned to the land under both systems of farming as they have much fertility value. The cornstalks should never be burned or otherwise destroyed as they have a real fertility value when plowed under in improving the crop producing and water holding powers of the soil. The second crop of clover at least should be plowed under and whenever the soil is very strikingly deficient in organic matter the entire clover or other legume crop should be turned under as a green manure.

It is quite generally necessary on the livestock farm to supplement the farm manure by treating the land with some other source of organic matter. The use of legumes as green manures is the cheapest and best means of making up the deficit of organic matter in the soil and at the same time adding to the nitrogen content by the use of inoculated legumes. When legumes are well inoculated, as they should be, they take up the free nitrogen from the atmosphere and may therefore add considerable amounts of the element to the soil when they are turned under for green manuring purposes. Thus they serve as nitrogenous fertilizers as well as sources of organic matter. On the grain farm or under any conditions where the supply of farm manure is entirely inadequate to keep up the organic matter in the soil, the use of legumes as green manures is very desirable. On many of the soils of Monroe County, green manuring with legumes would undoubtedly prove very much worth while and the practice will be of special value on the poorer, lighter colored soils. Even on the better soils, apparently better supplied with organic matter, it may be distinctly profitable. Green manuring should not be followed blindly or carelessly, however, as the results may prove quite undesirable if the green materials are not properly decomposed when plowed down. The practice should be included in regular farming operations in this county and should be followed carefully and according to approved methods in order that the land may be built up and kept up in fertility.

LIMING

The soils in Monroe County are all acid in reaction and show large needs for lime. The addition of limestone is, therefore, necessary for the best growth of general farm crops and particularly of legumes such as sweet clover and alfalfa. The fact that the best crops are not obtained on acid soils is quite generally recognized and the practice of liming such soils in order to provide conditions for the most economic production is also widely known. The dependence of alfalfa and sweet clover upon the presence of lime in the soils is readily discovered by any who have attempted to grow these crops on acid lands. Such attempts always end in failure, and the cost of the seeding is wasted. The fact that some crops such as corn and the small grains and also some of the legumes will grow on acid soils has, however, blinded many to the well-established fact that most of these crops will grow much better when the soil is limed. This is the case with soybeans, for example. Furthermore the liming of the land in the rotation for the best growth of the legume of the rotation leads to a better growth of the other crops like corn and the small grains, because of the greater amount and better character of the residues from the legumes. Thus there are indirect effects from the liming which make the practice beneficial to all the crops of the rotation. Then too it is not generally realized that in acid soils the proper biological processes are not going on and hence, because there is not a proper production of available plant food, crops may not be supplied with all the food that they need and may be limited in growth as a result. It is quite impossible to make and keep soils most profitably productive without liming when the land is acid. Growing crops without lime may serve as a temporary device to meet an economic situation in which funds are not available for the liming operation, but for a permanent program the liming of acid soils is absolutely essential.

The actual lime needs of individual soils can only be determined with accuracy by tests on the particular soil. The figures given earlier in this report show the needs of the samples tested but should be taken only as indications of the needs of these types as they occur in the field. Soils vary widely in lime requirements and even average figures from many tests will not give the proper amount of lime to use. By making tests of the soil in the particular field, it is possible to apply the proper amount of lime. This is important from the standpoint of obtaining the best results from the treatment and also from the standpoint of making neither too large nor too small an application, both of which are undesirable. Farmers may test their own soils for acidity or lime needs but it will usually prove more desirable for them to send small samples to the Soils Subsection of the Iowa Agricultural Experiment Station where the testing will be done free of charge and recommendations made for treatment.

It is recommended that the soils of this county be tested regularly in the rotation, preferably preceding the legume crop, in order that the conditions for the growth of the legume may be most satisfactory. One application of limestone will not suffice for all time, although the effects may continue to appear for much longer than one rotation. The length of time which may elapse before lime is needed again on soil, following the initial application to neutralize the acidity, will depend upon the soil conditions; hence the only safe way is to test the soil just before the legume crop of the rotation and thus insure the success of the crop. It is a comparatively simple matter to have the soil tested and it is a safeguard against failure of the crop.

The data reported earlier from the field experiments on two of the main soil types in this county show the beneficial effects of liming these acid soils, as measured in yields of general farm crops. The other soils in the county would respond in just as large or even a larger way to liming and hence the practice is a most economically desirable one. It is also most desirable and even necessary for the permanent fertility of the land.

THE USE OF COMMERCIAL FERTILIZERS

The analyses of the soils of the county have shown that the content of the element phosphorus is low. It is apparent that this plant nutrient will become deficient in the near future even if it is not actually deficient at the present time. It is certain that the supply of this element for crop growth is very limited and the use of a phosphate fertilizer to meet the needs of the crop for phosphorus is indicated as desirable. The experiments which have been described and the experiences of many farmers have shown the value of phosphates when applied to many of the soils which are found in this county and it seems quite certain that beneficial effects will be obtained from the application of phosphates at the present time.

The two phosphorus fertilizers which may be employed are rock phosphate and superphosphate. Both are available on the market and may be purchased commercially. In the superphosphate the element phosphorus is in an immediately available form and may be taken up by the plants directly. In the rock phosphate, on the other hand, the element must be changed into a form utilizable by plants and this change into an available form may take some time. Thus the superphosphate is generally considered a quicker-acting fertilizer. However, when the rock phosphate is in a very finely ground condition, as is true of much of the material now on the market, and the conditions in the soil are at the optimum for the decomposition or availability processes, the change of the phosphorus into an available form may occur with rapidity and furnish available phosphorus to the crop just as fast as it needs it. Under most of the conditions under which comparative experiments have been carried out in the past, with just as favorable conditions as possible, however, the largest effects of the rock phosphate have been obtained in the second season. This indicates the slower availability.

Rock phosphate is usually applied at the rate of 500 or 1,000 pounds per acre, once in a 4-year rotation, and superphosphate has generally been used at the rate of 120 pounds of the 20 percent material per acre 3 times in the 4-year rotation. Thus 360 pounds of the superphosphate are used in the rotation in comparison with either 500 or 1,000 pounds of the rock phosphate. Obviously the relative cost of the two applications will be of significance in determining which should be employed and in this connection whether the 500 or 1,000-pound application is employed will be of much importance. There is still some question whether the 500-pound amount will give the best results in the case of the rock phopshate but it is coming to be considered the most desirable application. Having that in mind, then, the thing to do is to compare the relative effects of the two materials on the crops grown and thus determine the relative value of the applications. There is little difference in the cost of the two materials in these amounts and if the effects are similar then the question is answered for the particular farm condition, and the farmer may apply either material with assurance of profit. Wherever the results appear better for one material then that should be employed on that farm.

The field experiments which have been discussed in previous pages have shown the value of rock phosphate and superphosphate when applied to two of the major soils of the county — the Grundy silt loam and the Clinton silt loam. Unquestionably the other soils in the county would show just as large or perhaps larger effects. The results at present available do not permit of a definite choice between the two phosphates, as sometimes the rock phosphate proves superior and sometimes the superphosphate is much better. The differences between the two materials are often very small. It is apparent from all the information we now have that the best way for any farmer to determine which phosphate will give the best results on his particular farm is to test both materials under comparable conditions, as has been suggested. Simple tests may be made on small areas and in this way the actual value of the fertilizers may be ascertained, and the material which would prove most desirable for the conditions will be shown. The indications at present all point to the fact that some phosphate will undoubtedly be worth while for use on the soils of the county.

The content of nitrogen in the soils of the county is sometimes apparently quite adequate and the black color of some of the soils would suggest that there is enough nitrogen, at least for the present. However, some of the types are light colored and lacking in nitrogen and the need of some nitrogenous fertilizing materials is evident. Such soils should receive additions of some nitrogen fertilizers now and in some instances liberal additions are needed. In all cases there should be provision for a regular addition of nitrogen to the soil of the county, if the supply is to be kept up and crop yields maintained, as the element is lost rather rapidly from soils by leaching and by crop removal.

The proper use of all the farm manure produced on the farm and the turning under of the crop residues supply considerable nitrogen and are very helpful in maintaining the nitrogen content of the soil. They return to the land much of the element which is taken out by the crops grown, but will usually prove inadequate to keep the nitrogen content constant. The method which will permit building up the nitrogren supply and will supplement the use of farm manure and crop residues is the turning under of legumes as green manures. These crops, when well inoculated, take much of their nitrogen content from the atmosphere and hence may enrich the soil considerably in nitrogen when they are plowed down. This is undoubtedly the cheapest and best method of increasing the nitrogen supply in the soil and it has the additional value that organic matter is also added in large amounts. Commercial nitrogenous fertilizers are usually not needed on the soils in this county as leguminous green manures will prove more desirable and distinctly cheaper. In small amounts as top dressings and for special crops they may be worth while, but general farm crops rarely need them. In any case such fertilizers should not be employed until tests have been carried out on a small area and the value of the treatment has been definitely shown for the soil and particular crop condition.

The soils of the county are probably quite adequately supplied with potassium and additions of commercial potassium fertilizers are not recommended for general use at present. There may be cases where such fertilizers would prove of value and then they should, of course, be used. It should be emphasized, however, that tests of such materials should be conducted on small areas before any extensive application is made. If the test proves the potassium fertilizer to be worth while then it may be applied to a large area with assurance of profit.

The application of certain complete commercial fertilizers may be desirable in some cases but for general farm crops it is improbable that these fertilizers would prove as profitable as superphosphate, owing to their greater cost and the fact that the effects on crop yields are usually quite similar. If the complete materials do bring about much larger crops, then they should be used without question. The only way to determine this is to try out the particular complete fertilizer in comparison with superphosphate, preferably on small comparable areas of land, and thus obtain exact data on the relative effects. There is not the slightest objection to the use of complete commercial fertilizers. It is entirely a matter of their actual value under field conditions and whether or not they prove more economically profitable than superphosphate. They do not wear out the land; they do not injure the soil when properly used. If tests show them to be of value they may be used with the assurance of success. But they should not be extensively applied to the land until they have been tested.

DRAINAGE

The natural drainage system of the county is well established and the map shown earlier in this report indicates that the rivers, creeks and their tributaries with the intermittent drainage lines extend into practically all parts of the uplands. There are areas, relatively small in size but nevertheless important agriculturally, however, where the drainage is not entirely adequate for the best crop growth. These small areas are found on the level uplands in the Grundy silt loam, the Putnam silt loam, and the Marion silt loam, on the terraces in the Bremer soils and the Calhoun silt loam and on the bottomlands where some of the Wabash areas are in need of drainage after they have been protected from overflow, if they are to be cropped. In all these cases drainage is the first treatment needed to make the land productive, for wherever land is not adequately drained crop yields will not be satisfactory.

The artificial drainage of land which is too wet may be somewhat expensive but it is essential if the land is to be cropped. Tiling such land will bring about results in the way of increased crop yields which will more than offset the cost of the operation. In general it may be emphasized that any land in this county which is not thoroughly drained must be tiled if it is to be made most satisfactorily and economically productive for general farm crops.

THE ROTATION OF CROPS

It is quite generally recognized now that the continuous growing of any one crop on the land will very quickly reduce the fertility of the soil and lead to a decrease in crop yields. Sometimes the decrease occurs immediately or within a few years and in other cases a number of years may elapse before any startling effect is noted. But the depression in crops is bound to occur sooner or later. In spite of the general knowledge of this fact, the profit from a certain crop often leads the farmer to follow the destructive one-cropping system and overlook the fertility depletion of the soil which he is causing. It is a matter of fact that even if crops of less money value are included in a rotation, the total value of all the crops grown over a period of years will be greater under the rotation because of the greater yields of the crops grown.

No rotation experiments have been carried out in this county but some rotations may be suggested which will undoubtedly prove of value under the various soil conditions in the area. From these suggested rotations, one may be chosen which will be suitable for almost any condition. Any of them may serve as a basis from which a suitable rotation may be developed for any particular farm condition. The following are suggested rotations:

1. Six-Year Rotations

First year—Corn
Second year—Small grain
Third year—Mixed hay
Fourth, fifth and sixth years—Rotation pasture

First year—Corn
Second year—Soybeans
Third year—Winter wheat
Fourth year—Mixed hay
Fifth and sixth years—Rotation pasture

First year—Corn
Second year—Corn
Third year—Small grain
Fourth year—Alfalfa
Fifth and sixth years—Alfalfa

First year—Corn
Second year—Corn
Third year—Small grain
Fourth year—Winter wheat
Fifth, sixth and possibly seventh years—Alfalfa

2. Five-Year Rotations

First year—Corn
Second year—Corn
Third year—Small grain
Fourth year—Mixed hay
Fifth year—Rotation pasture (this may be carried for 1 or 2 years additional, making a 6 or 7-year rotation)

First year—Corn
Second year—Small grain
Third year—Mixed hay
Fourth and fifth years—Rotation pasture

First year—Corn
Second year—Corn
Third year—Small grain
Fourth year—Winter wheat
Fifth year—Legume hay

First year—Corn
Second year—Small grain
Third year—Winter wheat
Fourth year—Mixed hay
Fifth year—Rotation pasture

First year—Corn
Second year—Soybeans
Third year—Corn
Fourth year—Small grain
Fifth year—Legume hay

3. Four-Year Rotations

First year—Corn
Second year—Corn
Third year—Small grain
Fourth year—Legume hay

First year—Corn
Second year—Small grain
Third year—Mixed hay
Fourth year—Rotation pasture

First year—Corn
Second year—Corn
Third year—Small grain
Fourth year—Sweet clover

First year—Corn
Second year—Small grain
Third and fourth years—Alfalfa

First year—Corn
Second year—Soybeans
Third year—Small grain
Fourth year—Legume hay

First year—Corn
Second year—Soybeans
Third year—Winter wheat
Fourth year—Legume hay

4. Three-Year Rotations

First year—Corn
Second year—Small grain
Third year—Legume hay

First year—Corn
Second year—Corn
Third year—Small grain (with sweet clover seeded with the small grain and plowed down the following spring)

First year—Corn
Second year—Small grain
Third year—Sweet clover

5. Two-Year Rotation

First year—Corn
Second year—Small grain (with sweet clover seeded with the small grain and plowed down the following spring)

THE PREVENTION OF EROSION

Erosion is the carrying away of surface soil by the free movement of water over the land or by the action of wind. There are three types of erosion: Sheet washing and gullying which are the result of the action of water and the erosion brought about by wind, leading to what are known as dust storms.

There is considerable erosion in Monroe County, both of the sheet and the gully type. The soils of the Shelby and Lindley series are most seriously affected by this destructive agency, many areas of these soils being practically ruined. The Clinton silt loam is also badly eroded in some areas, especially where it is poorly managed and the slopes are steep. Some erosion also occurs in the other upland types, especially where they adjoin the more rolling types. There are many areas in the county where some means of preventing or controlling the action of erosion should be adopted. In some cases the land will be totally ruined if some method of control is not soon put into operation.

Various methods of controlling and preventing erosion in Iowa are available for use and the particular method which should be followed in any particular case will depend upon the slope, the extent of the erosion which has occurred and other factors. In some instances a simple change in the farming methods may suffice, while in other cases extreme methods may be necessitated by the seriousness of the situation.

Those areas which are most severely washed and in which there are large gullies will need to be taken out of cultivation and either seeded down to permanent pasture, if this is possible, or planted to forest trees, shrubs or vines. Black locust trees have been used very successfully for planting in gullies throughout southern Iowa. Shrubs and certain vines are also sometimes used. The building of dams may sometimes be necessary in cases of extreme erosion. Various types of dam construction are possible according to the needs of the particular situation. In general where gullying is so extensive that it is impossible to fill the gullies or to reclaim the area, the main consideration is to prevent any further growth of the gully and to provide some vegetative cover along with any installation of dams which may be needed to do this. Trees often make the best cover.

For land which is suitable for cultivation there are certain methods of treatment and handling which will aid materially in preventing and controlling erosion. These treatments include cultivation, liming, the rotation of crops, the use of organic matter, and the application of phosphates and other fertilizers.

Cultivation

Proper cultivation is essential for the best crop production and also for the prevention of erosion.

Contour cultivation involves the cultivation of the land on the contours with the slopes rather than up and down the slopes as is so often the practice. This practice provides for the holding of water and the cutting down of the run-off. Contour cultivation has been found to be a very effective method of reducing erosion.

The basin-lister method of planting corn is a new method of cultivation which gives indication of having considerable value in controlling soil erosion. This method provides for catching and holding the water in storage basins which prevents the loss of the water and also stops erosion.

Terracing—The terrace as used in this country is a broad ridge with a shallow ditch on its upper side. The terrace diverts the run-off water into channels of low gradient or slope around the hill rather than allowing it to flow directly down the slope. The surface water from above the terrace is caught and led slowly away in the terrace channel. Thus surface run-off is prevented and more of the water is absorbed by the soil. Terraces are designed to suit the type of soil, the slope and the rainfall and may vary in type, height and distance between terraces. Land with slopes of 12–15 percent is usually the steepest that can be terraced. In all cases the run-off water from the terraces must be controlled by protected outlets which should be seeded and kept from injury by livestock or farm machinery. The proper cropping of the terraced land is extremely important in relation to the efficiency of the installation.

Grass Strips—Strips of grass in the natural drainageways are an important aid in preventing gully formation. The maintenance of a good sod in such drainageways is comparatively simple and very much worth while.

Dams [2]

Wherever gullies have been formed, some type of dam installation may be necessary to reduce the rate of flow of the run-off water and thus reduce its soil-carrying and cutting power. Such installations may be grouped under three headings: Temporary check dams, semi-permanent dams and permanent soil saving dams.

Temporary Check Dams—These dams are usually inexpensive and are built of temporary materials in medium or small gullies where the ultimate protection of the land is to be brought about by plant cover. The various types of brush and woven wire dams belong in this group.

Semi-Permanent Check Dams—This type of dams may be constructed of loose rock, logs or planks and when properly built and maintained have a reasonably long life and are effective. They are, however, more expensive to build.

Permanent Dams—These soil-saving dams are used in the medium and large gullies and are designed to catch and hold large quantities of water and especially the soil carried by the run-off and to prevent future erosion without dependence upon vegetation. Concrete and earth dams come in this group. Proper design and installation of these dams is essential to their efficiency and when they are built properly to meet the needs of the particular situation, they are very effective.

Crop Rotations

The proper rotation of crops to conserve the organic matter content of the soil is very important in connection with the erosion which occurs on the land as in this way the water-absorbing capacity is maintained and the rainfall run-off is decreased. Then too, proper rotations keep the soil covered and protected against the action of the run-off water. The growing of non-tilled crops prevents erosion to a very large extent and the alternation of inter-tilled and non-tilled crops will help materially in cutting down on erosion losses. In some cases it may be necessary to provide for a minimum of inter-tilled crops. The crops grown and the arrangement of the crops will affect the losses. Hay crops and pastures are the most effective in reducing erosion.

Strip Cropping—This involves the planting of alternate strips of non-tilled and inter-tilled crops on the contours. These strips may be 7 rods or more in width and various crops may be grown. Alfalfa may be alternated with corn, or additional strips of clover, oats or other crops may be included. Grass turn-

[2] Ayres, Q. C. — Recommendation for the Control and Reclamation of Gullies — Iowa Eng. Exp. Sta. Bul. 121.

ways are maintained at each end of the field. The strips may be rotated where the various crops of the rotation are included. A combination of contour cultivation and strip cropping has been found to be very effective in controlling erosion.

Winter Cover Crops—The proper use of winter cover crops will aid materially in preventing the losses of soil and water from land which is subject to erosion and from which large losses may occur in the fall, winter and early spring months. The use of rye or rye and vetch may be quite worth while as winter cover crops. These crops also add organic matter to the land and give additional aid in reducing erosion.

The Use of Legumes—The growing of most of the legumes, such as clover and alfalfa, is a very important and effective aid in reducing erosion. These deep-rooted plants not only keep the land covered but they add much organic matter and nitrogen to the soil when they are plowed down and thus increase the fertility of the land, which in turn reduces erosion.

Liming

The most desirable legumes, such as the clovers and alfalfa, cannot be established on acid soils and, as these crops should be included in the best rotations from various standpoints, it is important that lime be applied to the soils which are acid. Acid soils not only will not support the growth of most legumes but they are low in fertility and gradually become poorer and poorer in fertility. This soon ends in serious erosion on land which is at all subject to the destructive action of water. Low fertility means not only low crop yields but rapid increase in erosion losses. Liming acid soils is essential to permanent fertility of the land and is also very important in connection with the control of erosion.

Increasing the Organic Matter Content

The rate at which water is caught and held by soils and the amount which is retained for the use of subsequent plant growth is dependent very largely upon the organic matter content of the soil. Organic matter or humus increases the water-absorbing power and the water-holding power of soils and hence, when organic matter is supplied in the form of farm manure, residues, or leguminous green manures, there is a reduction in the erosion losses. The amount of this reduction depends upon the needs of the soil for organic matter. Experiments have shown that liberal applications of farm manure and plowing down sweet clover as a green manure not only improve the fertility of the land and the crop yields but they also reduce the erosion losses to a very large extent.

Application of Fertilizers

The use of phosphates and other fertilizers may be needed to insure the growth of the most desirable crops such as the legumes, and wherever the land is poor and relatively infertile it may be quite desirable to apply fertilizers in order to increase crops and, at the same time, reduce the erosion losses.[3]

[3] Further information regarding erosion and methods of prevention may be obtained in Iowa Agr. Exp. Sta. Special Rept. No. 2, Soil Erosion in Iowa, also in Iowa Agr. Ext. Serv. Bul. 172, Terracing to reduce erosion.

INDIVIDUAL SOIL TYPES IN MONROE COUNTY[4]

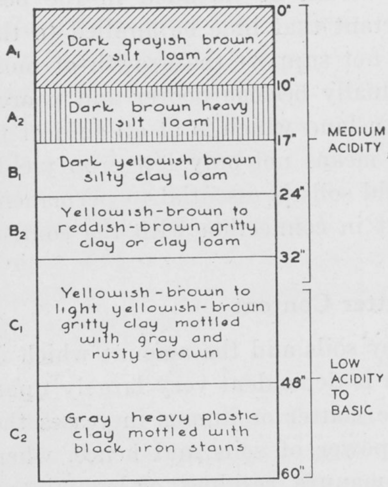
There are 18 soil types in Monroe County and an area of riverwash making a total of 19 soil areas. They are divided into five groups on the basis of origin and location. These groups are drift soils, loess soils, terrace soils, swamp and bottomland soils and residual soils.

DRIFT SOILS

Two drift soils are classified in the Shelby and Lindley series and together they cover 37.8 percent of the total area.

Shelby Silt Loam (93) (Ss)

The Shelby silt loam is the larger of the drift soils and the largest individual soil type in the county, covering 23.4 percent of the total area. It occurs in numerous extensive areas on the uplands in the hilly regions near the streams. The largest development of the type is in the western half of the county and particularly in Cedar, Wayne, Jackson and Guilford townships. There are many narrow irregular areas along the streams in other parts of the county.



TYPICAL SOIL PROFILE OF THE SHELBY SILT LOAM

The surface soil of the type—to a depth of about 7 to 10 inches—is a dark grayish-brown friable silt loam containing varying amounts of fine sand. The thickness of the surface layer varies with the topography, being greater on the crests of the hills and at the base of the slopes, while on the steeper slopes the entire layer of silty material may have been removed. The subsurface soil is a dark yellowish-brown, in other places a reddish-brown and in still others a gray or slate-gray. This lower subsoil is usually a heavy or gritty clay loam in texture. Boulders occur throughout the subsoil and increase with depth. Some carbonates occur in the lower depths of the soil, usually below 40 inches and often much deeper.

In topography the type is strongly rolling to hilly or broken over much of the area and less than 50 percent of the soil is now fit for cultivation and shows a topography which may be described as gently rolling. These gentler slopes are farmed to general farm crops, corn, oats, barley and hay. Corn is the principal crop while oats and hay are grown on the slopes which are already somewhat eroded and show definite evidences of losses. Crop yields are not high on the type owing to the shallowness of the surface soil and the erosion which has occurred so generally.

The soil is frequently too steep to be cultivated successfully and in such cases the land should be put into pasture or into forest trees. When it is cultivated

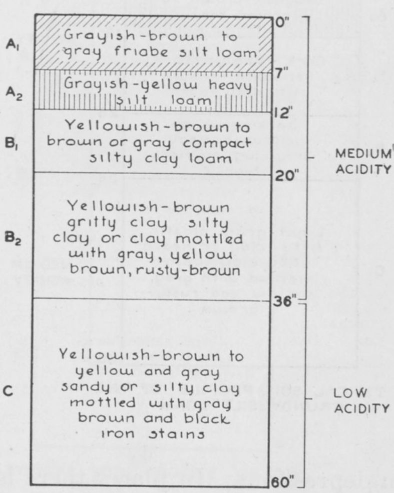
[4] The descriptions of the individual soil types given in this section of the report very closely follow those in the report of the Bureau of Chemistry and Soils.

it should be most carefully handled to prevent erosion according to the suggestions made earlier in this report. The soil is in need of additions of organic matter and liberal amounts of farm manure should be added or legumes should be turned under as green manures. The soil is acid in reaction and liming is essential especially for the growing of the most desirable legumes. The use of a phosphate fertilizer would help in permitting the best crop yields. Proper rotation of crops and methods of farming would aid materially in bringing about the most satisfactory crop yields and also in preventing the erosion of the land which is so destructive in so many cases.

Lindley Silt Loam (65) (Ls)

The Lindley silt loam is the second largest drift soil and the third largest soil type in the county. It covers 14.4 percent of the total area. It is found in extensive areas on the breaks near the streams, occupying the steeper slopes and narrower ridges adjacent to the streams. The most extensive development of the type is in Mantua, Urbana, Franklin, Wayne and Cedar townships.

The surface soil is a grayish-brown to brownish-gray or gray friable silt loam extending to an average depth of 7 inches. The depth of the surface layer is variable, being greater on the ridge tops and lower slopes and very thin or entirely absent on the upper slopes. The lower part of the surface layer is a heavy silt loam which is a grayish-yellow in color. The subsurface soil is a yellowish-brown plastic gritty clay to a depth of about 20 inches and the lower subsoil is a gray, brown and yellowish-brown silty clay loam containing some fine sand and boulders of different sizes. The color of the subsoil is sometimes a reddish-brown and it may be a clay in texture.



TYPICAL SOIL PROFILE OF THE LINDLEY SILT LOAM

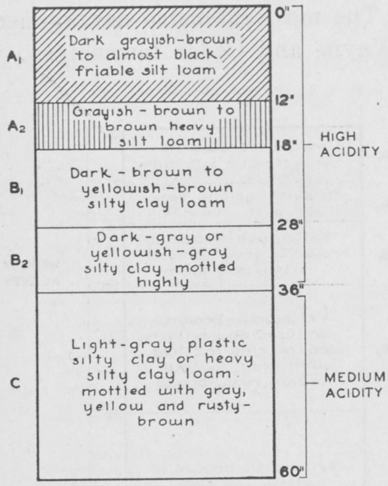
In topography the soil is hilly to broken, the slopes are steep and the land for the most part is uncultivable. A small part of the land has been cleared and attempts have been made to crop it but it is very difficult to prevent erosion and crop yields are low. It is quite impossible to keep such land under cultivation for any length of time and much of it has reverted to brush and grass. Some has been used for timber and the cut-over land has largely been allowed to grow up to second growth, often being useless for pasture purposes. The timbered areas are sometimes well covered with bluegrass and provide pasture, although the more heavily timbered land is of little value from the pasture standpoint. The type is much better kept in pasture or in timber and, if cultivated, satisfactory crops can only be obtained on the gentler slopes and with intensive methods of soil treatment for improving the fertility of the soil and for preventing erosion.

LOESS SOILS

There are 6 loess soils in the county classified in the Grundy, Weller, Clinton, Putnam, Edina and Marion series. Together they cover 44.9 percent of the total area of the county.

Grundy Silt Loam (64) (Gs)

The Grundy silt loam is the largest of the loess soils and it is the second largest soil type in the county. It covers 21.1 percent of the total area. It is extensively developed on the upland plain around Albia on the divides following the Chicago, Burlington and Quincy Railroad and State Highway No. 59, which extend northeasterly from Albia, and on the divide traversed by State Highway No. 60 from Albia north to Lovilia. Smaller areas of the type are developed in every township.



TYPICAL SOIL PROFILE OF THE GRUNDY SILT LOAM

The surface soil of the type is a dark grayish-brown friable silt loam extending to an average depth of 8 to 12 inches. When moist it appears very dark brown and in some places black. The lower part of the surface layer is a grayish-brown to brown heavy silt loam, being somewhat lighter in color and heavier in texture than the surface soil. The subsurface soil is a dark brown to yellowish-brown silty clay loam to a depth of about 28 inches. The subsoil is a dark gray silty clay highly mottled with yellow and brown. This subsoil is very tough and impervious to water and very hard when dry. The substratum is not quite so heavy and impervious as the typical subsoil. The depth of the surface soil varies from 8 inches to more than 17 in depth and the texture is sometimes a very heavy silt loam, especially in depressions. In places there is a gray color or the beginning of the development of a gray subsurface layer. Where the areas of this variation are of sufficient size they are separated as the Edina silt loam. Frequently the subsoil of the type, where it adjoins other types, may be a yellowish-brown in color.

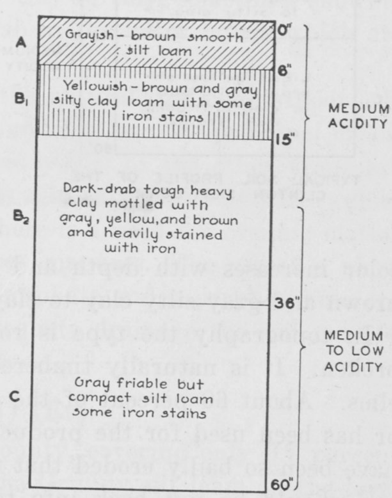
In topography the type is very gently rolling to almost flat. In the level areas natural drainage is poor and tiling is necessary. The slightly rolling areas are usually adequately drained but may be in need of drainage too, as the heavy subsoil of the type prevents the rapid removal of water by underdrainage.

The type is all under cultivation and it is a highly productive type when it is well drained and properly managed. The average yields of corn are about 35 bushels per acre but those farmers who practice the best methods of soil management obtain as high as 75 bushels. Other crops yield correspondingly high when the land is in good condition. In addition to drainage when needed, the soil will respond to liming as it is acid in reaction and the best legumes will not grow without the application of the necessary amount of lime. The soil will be benefited also by the addition of organic matter in the form of farm manure or of leguminous green manures. The application of a phosphate fertilizer has been found to be of value and such fertilizers may often prove distinctly profitable. The experiments discussed earlier in this report showed the beneficial influence of the use of limestone, organic matter and phosphates in bringing about the best crop yields. Such methods of soil management as are included in proper crop rotations, proper cultivation and the thorough utilization of crop residues are of considerable value on this soil but need no special emphasis as they are commonly followed.

Weller Silt Loam (261) (We)

The Weller silt loam is the second largest loess soil in the county and the fourth largest type. It covers 13.1 percent of the total area of the county. It occurs in numerous narrow strips in the hilly sections of the county near the streams, occupying a position on the narrow ridges and steep slopes. It is developed to the greatest extent in Pleasant, Cedar and Guilford townships.

The surface soil of the type, averaging 6 inches in depth, is a grayish-brown smooth silt loam. The depth of the soil is variable, some slopes and ridges being completely denuded of soil while in other areas it may be deeper. The subsurface soil — to a depth of 15 inches — is a yellowish-brown and gray silty clay loam which gradually becomes heavier with depth and shows some iron stains. The subsoil is a dark drab tough heavy clay mottled with gray, yellow and brown and heavily stained with iron. The substratum is a gray friable but compact silt loam with some iron stains. Below 20 inches the subsoil is often a mottled gray and yellowish-brown and variously stained with iron.

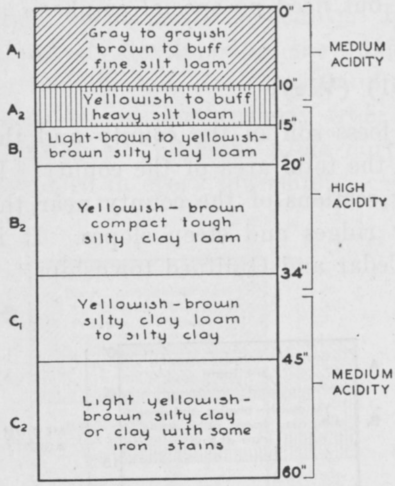


TYPICAL SOIL PROFILE OF THE WELLER SILT LOAM

In topography the soil is rough to hilly and broken, less than one-fourth of it being cultivated at present. The steepness of the slopes and the shallowness of the soil make it undesirable as crop land. Many areas have been so seriously eroded that the subsoil is exposed, no surface soil remaining. The area under cultivation is used mainly for hay land and the remainder serves as pasture. When cultivated the greatest care must be taken to prevent erosion. Proper cropping and handling of the soil is essential to permit of satisfactory cultivation even where the topography will permit. The soil is acid and needs liming for the growth of legume crops and other hay crops. The use of liberal amounts of organic matter is necessary on cultivated areas and phosphate fertilizers would help materially in improving crop yields.

Clinton Silt Loam (80) (Cm)

The Clinton silt loam is the third largest loess soil in the county and it is the sixth type in size in the area. It covers 7.9 percent of the county. It occurs in numerous areas of widely varying size in all parts of the county. It is most largely developed in Union, Pleasant and Urbana townships. It is developed on the heavily wooded slopes near the streams where the topography is hilly, and on the cleared areas adjacent to the streams where the topography is rolling to strongly rolling.



TYPICAL SOIL PROFILE OF THE CLINTON SILT LOAM

The surface soil of the type — to a depth of about 10 inches on the average — is a grayish-brown to gray or brownish-gray smooth friable silt loam. When wet it appears a light brown but it dries to a gray and in some places to almost a white color. The depth of the soil varies considerably in different areas depending upon the topography and the cultivation. On the steeper slopes the surface soil is often completely removed and the subsoil is exposed, while in the areas which are not so steep and are uncultivated the soil is deeper. The lower surface layer — to a depth of 15 inches — is a yellowish to buff heavy silt loam. The subsurface soil — to a depth of 20 inches — is a light brown to yellowish-brown silty clay loam. The subsoil is a yellowish-brown and gray compact plastic heavy clay. The gray color increases with depth and the substratum is a light yellowish-brown to brown and gray silty clay to clay with some iron stains.

In topography the type is rolling to strongly rolling to steep, rough and broken. It is naturally timbered with white oak, hickory, red oak and some elms. About 60 percent of the area in the type has been cleared and is now or has been used for the production of crops. Some of these cultivated areas have been so badly eroded that they are of no value for crop production now and should be put back into timber or seeded down to permanent pasture. Probably one-fifth of the once cultivated areas of this type have been so seriously injured by erosion that they cannot be farmed any longer.

On the cultivated areas general farm crops are grown but crop yields are low. Corn yields about 30 bushels per acre, small grains and hay crops correspondingly low. Under proper methods of soil management large increases in crops might be obtained. The soil is acid in reaction and in need of lime, especially for growing the legumes which are needed on the land. The use of farm manure and legumes as green manures is necessary in order to build up the supply of organic matter and make the soil more productive and at the same time prevent erosion on the rolling areas. The soil must always be protected from erosion when it is cultivated, owing to its erodibility, and the proper rotation of crops with the inclusion of a legume and the increasing of the organic matter content of the soil by using the legume crop as a green manure, along with the liming which is necessary to permit of growing the most desirable legumes, will insure the best crop growth and at the same time prevent erosion or control it. Phosphate fertilizers will also make the soil more productive and are desirable for use in many cases on this land.

Putnam Silt Loam (66) (P)

The Putnam silt loam is a minor loess soil in the county, covering 1.7 percent of the total area. It is found on narrow flat ridges, mainly in areas surrounded by woodland, but it has never been timbered. It is developed in many small irregular shaped areas on the uplands, chiefly in the southern part of the county and especially in Monroe Township. There are no large individual areas of the type.

The surface soil of the type is a grayish-brown smooth friable silt loam extending to a depth of about 8 or 9 inches. The lower surface layer is a floury or ashy silt loam, gray to white in color, and extending to a depth of 16 inches on the average. Numerous iron stains and soft iron accumulations give the layer a streaked or mottled appearance. The subsurface soil is a yellowish-brown silty clay loam mottled with gray and rusty-brown iron concretions. The subsoil is a drab, gray or yellowish-brown silty clay to clay, sometimes showing mottlings of brown and yellowish-brown or drab in the lower layers which are distinctly gray.

The type is nearly level in topography and the natural drainage is poor. It is practically all farmed and corn, oats, barley and hay are the principal crops. Corn yields from 20 to 35 bushels per acre and yields of the other crops are similarly low. The soil needs to be limed as it is acid in reaction and if legumes are to be grown, the use of lime is essential. There is a need for organic matter in the form of farm manure or legumes as green manures. The use of a phosphate fertilizer would help and tests of rock phosphate and superphosphate are suggested. By these treatments along with adequate drainage the soil may be built up in fertility and made more productive.

Edina Silt Loam (211) (Es)

The Edina silt loam is a minor soil in the county, covering only 0.7 percent of the total area. It is found associated with the Grundy silt loam on the level divides in isolated spots, most of which are slightly depressed or extremely flat, within large areas of the Grundy silt loam. The bodies range in size from less than 1 acre to more than ½ square mile. The areas are found mainly in the four southern townships.

The surface soil of the type — to a depth ranging from 5 to 12 inches — is a very dark grayish-brown silt loam. It is almost black when wet. The lower surface layer is a gray to almost white fine floury silt loam which is quite compact and varies in depth from 3 to 10 inches. The subsurface soil — to a depth of about 30 inches — is a dark drab to grayish-brown compact silty clay to clay. The subsoil is a gray silty clay mottled with brown, yellow and rusty-brown.

In topography the Edina silt loam is flat to slightly depressed and the drainage is poor, as the gray compact silty layer and the very impervious subsoil hinder the movement of water. The type is all cropped with the Grundy soils and the yields are somewhat lower owing to the lower fertility, differences of 8 to 12 bushels of corn per acre from the yields on the Grundy soils being reported.

This soil needs adequate drainage first of all, if it is to be most satisfactorily cultivated. It then must be limed to correct the acidity and to permit the best growth of the desirable legumes. It will respond to the use of farm manure or to the turning under of legumes as green manures, as there is a need for organic matter to make the soil more productive. The use of a phosphate fertilizer would help and tests of superphosphate and rock phosphate are suggested. With proper methods of soil management the type may be made more satisfactorily productive.

Marion Silt Loam (67) (M)

The Marion silt loam is a very minor soil type in the county, covering only 0.4 percent of the total area. It occupies the narrow flat ridges in the wooded sections of the county. There are many small areas of the type, chiefly in Franklin Township. No large areas of the type are found.

The surface soil of the type — to a depth of about 7 inches — is a light grayish-brown to gray or nearly white smooth floury silt loam. The lower surface layer is a gray to white floury compact silt loam. This layer is 8 to 10 inches in depth. The subsurface soil — to a depth of 21 inches — is a gray and brown heavy clay loam to silty clay loam. The subsoil, extending to 29 inches, is a grayish-brown compact silty clay to clay. The subsoil becomes lighter in color and lighter textured in the lower depths and the substratum is a gray and brown silty clay loam with iron stains and some mottlings.

In topography the Marion silt loam is flat to depressed and the natural drainage is poor. It is mostly cultivated but crop yields are low. Corn yields as low as 15 bushels per acre and other crop yields are equally poor. The type needs adequate drainage, then it must be limed to correct the acidity, after which there must be a large incorporation of organic matter. The liberal use of farm manure or the turning under of legumes as green manures is very necessary to improve the fertility conditions of the type. The use of a phosphate fertilizer would also help to provide better conditions for crop growth.

TERRACE SOILS

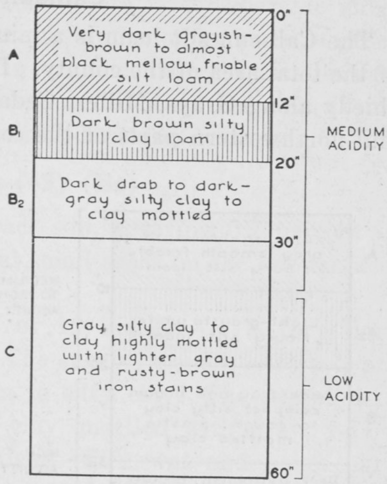
There are 7 terrace soils in the county and together they cover 1.9 percent of the total area. They are classified in the Bremer, Chariton, Calhoun, Waukesha and O'Neill series.

Bremer Silt Loam (88) (B)

The Bremer silt loam is the largest of the terrace soils, being found on 1.1 percent of the total area of the county. It is mapped in numerous small areas along the larger streams of the county, on the low terraces or second bottoms. The largest development is along the Cedar, North Cedar, Miller and Avery creeks.

The surface soil of the type — to a depth of about 12 inches — is a very dark grayish-brown to almost black, mellow, friable silt loam. The soil appears black when wet and becomes somewhat sticky. The subsurface soil to a depth of 20 inches is a dark brown silty clay loam with some mottling and staining with gray, yellowish-brown, rusty-brown and black. The subsoil to a depth of 3 feet is a dark drab to dark-gray silty clay to clay mottled with gray, yellow and rusty-brown. It is heavy, compact and very impervious.

In topography the type is level to flat and the natural drainage is poor. The larger areas need artificial drainage. When well drained the yields of crops are good. General farm crops are grown and corn yields 45 bushels per acre, for example, under favorable conditions. Other crops yield similarly, although there is a tendency for the small grains to lodge especially in some seasons.

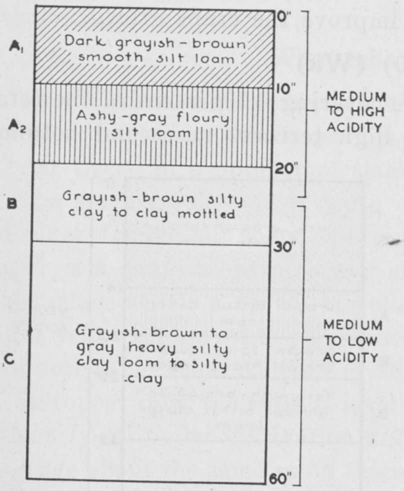


TYPICAL SOIL PROFILE OF THE BREMER SILT LOAM

The soil needs first of all to be adequately drained if it is to be made most satisfactorily productive. It is acid in reaction and must be limed for the best results and particularly if the legumes are to be grown. It will be benefited by organic matter additions although the soil is not so deficient in this constituent as some of the other types. It will respond to the application of a phosphate fertilizer and tests of rock phosphate and superphosphate are recommended.

Chariton Silt Loam (105) (Ch)

The Chariton silt loam is a minor type in the county, covering 0.3 percent of the total area. It is the second largest terrace soil. It is found in several areas along the major streams in the northwestern part of the county, especially along the Cedar and Whites creeks.



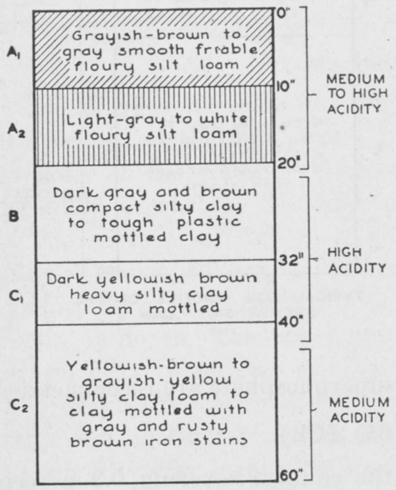
TYPICAL SOIL PROFILE OF THE CHARITON SILT LOAM

The surface soil of the type — to a depth of about 10 inches — is a dark grayish-brown smooth silt loam, which appears very dark brown or black when wet. The lower surface layer — to a depth of about 20 inches — is a very fine or floury gray or almost white silt loam, which is sometimes slightly mottled, and contains some yellow, brown and black iron stains. The subsoil — to a depth of 30 inches — is a grayish-brown silty clay to clay mottled with yellow, drab and brown and often some rusty-brown. Gray and drab colors increase with depth.

In topography the type is level and the natural drainage is fair. In some cases it is deficient owing to the topographic position and the heavy impervious subsoil. Practically all of it is under cultivation and general farm crops are grown. The yields are not as good as on the adjacent uplands of the Grundy series but they are fairly satisfactory. They may be increased materially by proper methods of management, including the providing of adequate drainage, liming to correct the acidity, the application of organic matter and the use of a phosphate fertilizer.

Calhoun Silt Loam (42) (Cl)

The Calhoun silt loam is a minor terrace soil type, covering only 0.1 percent of the total area of the county. It occurs in narrow areas on the second bottoms chiefly along Grays, Miller, Cedar and North Cedar creeks in the northeastern and northwestern parts of the county.



TYPICAL SOIL PROFILE OF THE CALHOUN SILT LOAM

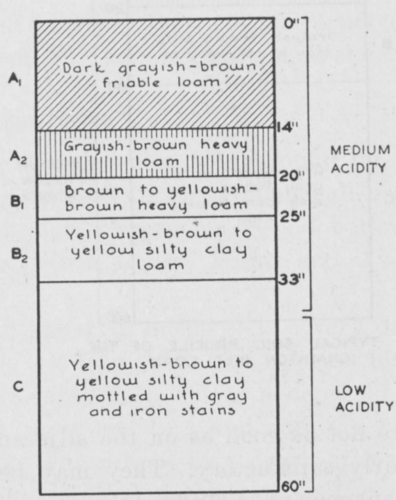
The surface soil of the type — to an average depth of 10 inches — is a grayish-brown to gray smooth, friable, floury silt loam. The lower surface layer — to a depth of about 20 inches — is a light gray to white floury silt loam. The subsoil is a dark gray and brown compact silty clay to tough plastic mottled clay. It is often mottled with gray, yellow, rusty-brown and black iron stains.

In topography the type is level to flat and the natural drainage is poor. Most of the type is cropped to general farm crops but the yields are low, generally as low as on the Marion soils on the uplands, which the type resembles. The soil needs adequate drainage as the first requisite for good crop production, then it should be limed in order to correct the acidity and permit the growth of the best legumes. It is in need of organic matter and should receive liberal applications of farm manure or legumes turned under as green manures. The addition of a phosphate fertilizer would also improve the crops grown.

Waukesha Loam (60) (Wk)

The Waukesha loam is a minor terrace type, covering 0.1 percent of the total area of the county. It is developed on the high terraces or second bottoms along Cedar and Grays creeks.

The surface soil of the type — to a depth of 14 inches — is a dark grayish-brown friable loam. The lower part of the surface layer — to a depth of 20 inches — is a grayish-brown heavy loam. The subsurface soil — to a depth of about 25 inches — is a brown to yellowish-brown heavy loam. The subsoil is a yellowish-brown to yellow silty clay loam, containing some fine sand and showing some faint gray mottlings and iron stains.



TYPICAL SOIL PROFILE OF THE WAUKESHA LOAM

The type is level to flat or gently sloping and the natural drainage is good. The soil is all cultivated and the crop yields are good. They may be increased, however, by proper management. The soil is acid and in need of lime in order to permit the growing of legumes. There is considerable effect from the application of farm manure or the turning under of legumes as green manures, although the soil is not as deficient in organic matter as is the case with some of the other types. The use of a phosphate fertilizer has been found to be of value in many cases and tests are certainly desirable.

Bremer Silty Clay Loam (43) (Bs)

The Bremer silty clay loam is a minor terrace soil, covering 0.1 percent of the total area of the county. It occurs in several small areas on the low terraces along Cedar Creek.

The surface soil of the type — to a depth of 12 inches — is a very dark grayish-brown to black friable silty clay loam. The subsurface soil — to a depth of 22 inches — is a dark brown silty clay loam to silty clay. The subsoil is a dark drab to dark gray compact silty clay to clay, mottled with gray, yellow and brown iron stains. The surface soil is sticky when wet and bakes hard when dried. In dry seasons large cracks may appear on the surface and extend into the subsoil.

In topography the type is flat to depressed and the natural drainage is very poor. About one-half of the soil is under cultivation and the remainder supports a rank growth of slough grass. Corn is the chief crop grown on the cultivated areas. Small grains are apt to lodge. The soil needs to be adequately drained if it is to be made productive. It is acid in reaction and must be limed for the best growth of all crops and particularly of legumes, such as the clovers. The use of small amounts of farm manure would prove of value in stimulating the production of available plant food in the soil. The addition of a phosphate would also help and tests of rock phosphate and superphosphate are recommended.

Waukesha Silt Loam (75) (Ws)

The Waukesha silt loam is a minor terrace soil in the county, covering only 0.1 percent of the total area. It is found on high well-drained terraces along Cedar Creek in a number of small areas.

The surface soil — to a depth of about 14 inches — is a dark grayish-brown to black friable silt loam, containing some very fine sand. The lower surface layer is a grayish-brown heavy silt loam to a depth of about 20 inches. The subsurface soil is a brown to yellowish-brown silty clay loam. The subsoil is a light yellowish-brown to yellow heavy silty clay loam. A few faint gray streaks are noticeable below a depth of 38 inches.

In topography the type is level to slightly sloping and it is well drained. It is nearly all under cultivation and general farm crops are grown. Corn yields average about the same as on the upland Grundy and other crops very similarly. Yields are ordinarily very good, but increases in crops may be obtained with better methods of soil management. The soil is acid and must be limed for the growth of legumes and for the best results with other crops. The use of farm manure and the turning under of legumes as green manures will be worth while and the use of a phosphate fertilizer will undoubtedly give profitable results. Tests of phosphates are recommended.

O'Neill Fine Sandy Loam (110) (Of)

The O'Neill fine sandy loam is a minor soil type, occurring on the terraces chiefly along Cedar Creek, in several small areas. It covers only 0.1 percent of the county.

The surface soil of the type — to a depth of 10 inches — is a dark brown or dark grayish-brown fine sandy loam. The lower surface layer is a dark brown to brown heavy fine sandy loam to a depth of 16 inches. The subsurface soil — to a depth of 24 inches — is a yellowish-brown to brown fine sandy loam to fine sand. The subsoil is a yellowish-brown to light brown fine to coarse sand.

The type is level or hummocky in topography, the slight rises being more sandy than the surrounding soil. The areas are well above overflow and the sandy character of the subsoil makes the land drouthy. The entire acreage is under cultivation and is used for the production of corn and oats. Yields are fair in favorable seasons but may be quite low in dry years. The soil needs lime to correct the acidity and permit legume growth and it is particularly in need of large additions of organic matter. Farm manure should be applied in large amounts and legumes should be turned under as green manures to build up the supply of organic matter and make the crops less subject to drouth injury. The use of a phosphate fertilizer would also help and tests of superphosphate are suggested.

SWAMP AND BOTTOMLAND SOILS

There are two areas of swamp and bottomland soils, both in the Wabash series, and an area of riverwash, making three areas in this group of soils. Together they cover 10.8 percent of the total area of the county.

Wabash Silt Loam (26) (Wl)

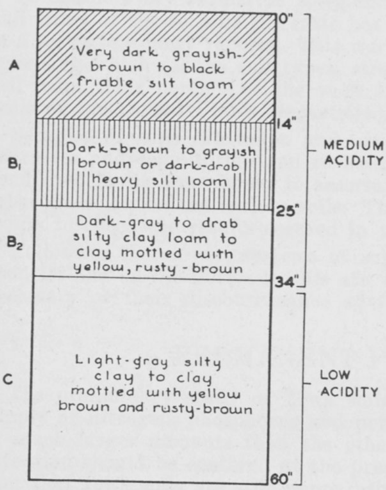
The Wabash silt loam is the largest of the bottomland soils and the fifth largest soil type in the county. It covers 10.5 percent of the total area. It occurs in numerous areas along the various streams in the county. Most of the areas are narrow, those along the Cedar Creek being the widest and most extensively developed.

The surface soil of the type is a very dark grayish-brown to black friable silt loam to a depth of 14 inches. The subsurface soil — to a depth of 25 inches — is a dark brown to grayish-brown or dark drab heavy silt loam to silty clay loam. The subsoil is a dark gray or drab silty clay loam to silty clay or clay mottled with brown, yellow and rusty-brown. In some areas there is more sand than is typical and this is especially true in the narrow areas along the smaller streams. The area next to the stream is also generally most sandy.

The large areas along Cedar Creek are farmed to some extent but crops are uncertain owing to overflows. Corn is grown mainly and the yields are good in favorable seasons. Most of the narrower areas cannot be cropped and are used for pasture purposes. In many cases excellent pasturage is provided. The soil needs protection from overflow for the larger areas if they are to be satisfactorily cropped and it will then respond to the use of lime to correct acidity, the addition of small amounts of farm manure to stimulate plant food production in an available form, and the use of a phosphate fertilizer. With these treatments crop yields may be increased and maintained.

Wabash Silt Loam (Colluvial Phase) (26 a) (Wl — x)

The colluvial phase of the Wabash silt loam is a very minor type in the county, covering only 0.2 percent of the total area. It is found at the bases of slopes and along some of the small upland draws. The material has been washed down from the slopes during heavy rains and redeposited over the broad areas of bottomland. The largest area is mapped along Avery Creek in Mantua Township and covers 80 acres. Other smaller areas are found.



TYPICAL SOIL PROFILE OF THE WABASH SILT LOAM

The surface soil of the phase is a dark brown to black mellow silt loam to a depth of 14 inches. The subsurface soil is a dark brown to almost black heavy silt loam to silty clay loam to a depth of 20 inches. The subsoil is a dark brown silty clay loam to clay mottled with yellow and drab.

The topography of the type is level to slightly sloping and the natural drainage is fair. It is practically all cropped and general farm crops are grown. Yields of corn and the small grains are good. Hay yields are excellent. The soil may be improved in fertility by proper management. The type is acid in reaction and must be limed for the best crops. The use of small amounts of farm manure would prove of value and additions of phosphate fertilizers will undoubtedly aid materially in increasing crop yields.

Riverwash (43) (Rv)

There is a small area of riverwash in the county, amounting to 0.1 percent of the total area. It consists of sandy and gravelly material deposited on the bottomlands and is found along the Des Moines River. The character of the material varies with every flood and it is valueless for agricultural purposes.

RESIDUAL SOIL

There is one residual soil in the county, mapped in the Dubuque series and it covers 4.6 percent of the total area of the county.

Dubuque Silt Loam (183) (Ds)

The Dubuque silt loam is the seventh largest individual soil type in the county. It is found mainly in the northern half of the county on the uplands adjacent to the streams and their tributaries. It occurs on the steep to almost precipitous slopes. It is developed along the Cedar, Whites and Bluff creeks, the largest areas being mapped in Union Township along Cedar Creek.

The surface soil of the type is a grayish-brown mellow silt loam to a depth of about 8 inches, ranging in color from a brownish-gray to a dark brown. The subsurface soil — to a depth of 22 inches — is a yellowish-brown to yellow silty clay loam. The subsoil is a yellowish-brown or reddish stiff gravelly clay. The substratum is lime rock.

In topography the soil is steeply rolling to rough and almost precipitous. Rock and shale outcrop at the base of slopes. The surface soil is often very thin, and the lime rock may appear. The soil cannot be cultivated and most of it is covered by a growth of oaks, hickory, elm and basswood. Some of it is utilized for pasture but in some cases the slopes are too steep to make it of any value for pasture purposes. In such instances it is classed as waste land.

APPENDIX

THE SOIL SURVEY OF IOWA

What soils need to make them highly productive and to keep them so, and how their needs may be supplied, are problems which are met constantly on the farm today.

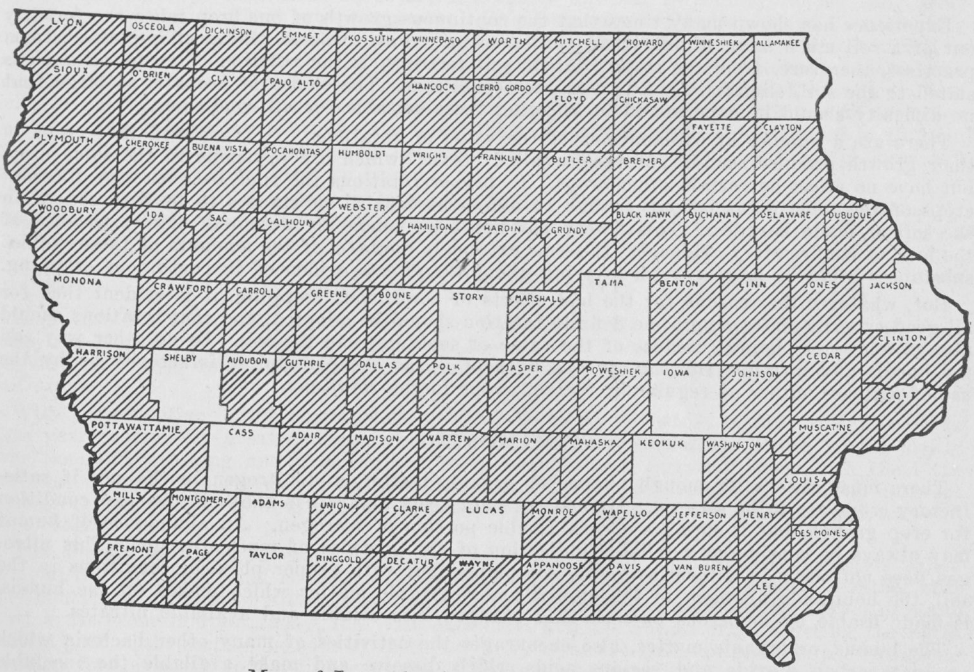
To enable every farmer to solve these problems for his local conditions, a complete survey and study of the soils of the state has been undertaken, the results of which will be published in a series of county reports. This work includes a detailed survey of the soils of each county, following which all the soil types, streams, roads, railroads, etc., are accurately located on a soil map. This portion of the work is being carried on in cooperation with the Bureau of Soils of the United States Department of Agriculture.

Samples of soils are taken and examined mechanically and chemically to determine their character and composition and to learn their needs. Pot experiments with these samples are conducted in the greenhouse to ascertain the value of the use of manure, fertilizers, lime and other materials on the various soils. These pot tests are followed in many cases by field experiments to check the results secured in the greenhouse.

Following the survey, systems of soil management which should be adopted in the various counties and on the different soils are worked out, old methods of treatment are emphasized as necessary or their discontinuance advised, and new methods of proved value are suggested.

PERMANENT FERTILITY IN IOWA SOILS

The preliminary study of Iowa soils revealed the fact that there is not an inexhaustible supply of nitrogen, phosphorus and potassium in the soils of the state. Potassium was found in much larger amounts than the other two elements, and it was concluded, therefore, that attention should be centered at the present time on nitrogen and phosphorus. In spite of the fact that Iowa soils are still comparatively fertile and crops are still large, there is abundant evidence at hand to prove that the best possible yields of certain crops are not being obtained



Map of Iowa showing the counties surveyed.

in many cases because of the lack of necessary plant foods or because of the lack of proper conditions in the soil for the growth of plants and the production, by bacteria, of available plant food.

Proper systems of farming will insure the production of satisfactory crops, and the maintenance of permanent fertility and the adoption of such systems should not be delayed until the crop yields are much lower, for then it will involve a long, tedious and very expensive fight to bring the soil back to a fertile condition. If proper methods are put into operation while comparatively large amounts of certain plant foods are still present in the soil, it is relatively easy to keep them abundant and attention may be centered on other elements likely to be limiting factors in crop production.

Soils may be kept permanently fertile by adopting certain practices which will be summarized here.

CULTIVATION AND DRAINAGE

Cultivation and drainage are two of the most important farm operations in keeping the soil in a favorable condition for crop production, largely because they help control the moisture.

The moisture in soils is one of the most important factors governing crop production. If the soil is too dry, plants suffer for lack of water necessary to bring them their food and also for lack of available plant food. Bacterial activities are so restricted in dry soils that the production of available plant food practically ceases. If too much moisture is present, plants likewise refuse to grow properly because of the exclusion of air from the soil and the absence of available food. Decay is checked in the absence of air; all beneficial bacterial action is limited and humus, or organic matter, containing plant food constituents in an unavailable form, accumulates. The infertility of low-lying, swampy soils is a good illustration of the action of excessive moisture in restricting plant growth by stopping aeration and limiting beneficial decay processes.

While the amount of moisture in the soil depends very largely on the rainfall, any excess of water may be removed from the soil by drainage, and the amount of water present in the soil may be conserved during the periods of drouth by thorough cultivation or the maintaining of a good mulch. The need for drainage is determined partly by the nature of the soil, but more particularly by the subsoil. If the subsoil is a heavy, tight clay, a surface clay loam will be rather readily affected by excessive rainfall. On the other hand, if the surface soil is sandy, a heavy subsoil will be of advantage in preventing the rapid drying out of the soil and also in checking losses of valuable matter by leaching.

THE ROTATION OF CROPS

Experience has shown many times that the continuous growth of one crop takes the fertility out of a soil much more rapidly than a rotation of crops. One of the most important farm practices, therefore, from the standpoint of soil fertility, is the rotation of crops on a basis suited to the soil, climatic, farm and market conditions. The choice of crops is so large that no difficulty should be experienced in selecting those suitable for all conditions.

There are a number of explanations of the value of rotations. It is claimed that crops in their growth produce certain substances called "toxic" which are injurious to the same crop, but have no effect on certain other crops. In proper rotations the time between two different crops of the same plant is long enough to allow the "toxic" substances to be disposed of in the soil or made harmless. This theory has not been commonly accepted, chiefly because of the lack of confirmatory evidence. It seems extremely doubtful if the amounts of these "toxic" substances could be large enough to bring about the effects evidenced in continuous cropping.

But, whatever the reasons for the bad effects of continuous cropping, it is evident that for all good systems of farming some definite rotation should be adopted, and that rotations should always contain a legume, because of the value of such crops to the soil. In no other way can the humus and nitrogen content of soils be kept up so cheaply and satisfactorily as by the use of legumes, either as regular or "catch" crops in the rotation.

MANURING

There must always be enough humus, or organic matter, and nitrogen in the soil if satisfactory crops are to be secured. Humus not only keeps the soil in the best physical condition for crop growth, but it supplies a considerable portion of nitrogen. An abundance of humus may always be considered a reliable indication of the presence of much nitrogen. This nitrogen does not occur in a form available for plants, but with proper physical conditions in the soil, the nonusable nitrogen in the animal and vegetable matter which makes up the humus, is made usable by numerous bacteria and changed into soluble and available nitrates.

The humus, or organic matter, also encourages the activities of many other bacteria which produce carbon dioxide and various acids which dissolve and make available the insoluble phosphorus and potassium in the soil.

Three materials may be used to supply the organic matter and nitrogen of soils. These are farm manure, crop residues and green manure, the first two being much more common.

By using all the crop residues, all the manure produced on the farm, and giving well-inoculated legumes a place in the rotation for green manure crops, no artificial means of maintaining the humus and nitrogen content of the soils need be resorted to.

THE USE OF THE PHOSPHORUS

Iowa soils are not abundantly supplied with phosphorus. Moreover, it is not possible by the use of manures, green manures, crop residues, straw, stover, etc., to return to the soil the entire amount of that element removed by crops. Crop residues, stover and straw merely return a portion of the phosphorus removed, and while their use is important in checking the loss of the element, they cannot stop it. Green manuring adds no phosphorus that was not used in the growth of the green manure crop. Farm manure returns part of the phosphorus removed by crops which are fed on the farm, but not all of it. While, therefore, immediate scarcity of phosphorus in Iowa soils cannot be positively shown, analyses and results of experiments show that in the more or less distant future, phosphorus must be applied or crops will suffer for a lack of this element. Furthermore, there are indications that its use at present would prove profitable in some instances.

Phosphorus may be applied to soils in three commercial forms, bone meal, superphosphate and rock phosphate. Bone meal cannot be used generally, because of its extremely limited production, so the choice rests between rock phosphate and superphosphate. Experiments are now under way to show which is more economical for farmers in the state. Many tests must be conducted on a large variety of soil types, under widely differing conditions and through a rather long period of years. It is at present impossible to make these experiments as complete as desirable, owing to small appropriations for such work, but the results secured from the tests now in progress will be published from time to time in the different county reports.

Until such definite advice can be given for individual soil types, it is urged that farmers who are interested make comparisons of rock phosphate and superphosphate on their own farms. In this way they can determine at first hand the relative value of the two materials. Information and suggestions regarding the carrying out of such tests may be obtained upon application to the Soils Subsection.

LIMING

Practically all crops grow better on soil which contains lime, or in other words, on one which is not acid. As soils become acid, crops grow smaller, bacterial activities are reduced and the soil becomes infertile. Crops are differently affected by acidity in the soil; some refuse to grow at all; others grow but poorly. Only in a very few instances can a satisfactory crop be obtained in the absence of lime. Therefore, the addition of lime to soils in which it is lacking is an important principle in permanent soil fertility. All soils gradually become acid because of the losses of lime and other basic materials through leaching and the production of acids in the decomposition processes constantly occurring in soils. Iowa soils are no exception to the general rule, as was shown by the tests of many representative soils reported in Bulletin No. 151 of this station. Particularly are the soils in the Iowan drift, Mississippi loess and Southern Iowa loess areas likely to be acid.

All Iowa soils should therefore be tested for acidity before the crop is seeded, particularly when legumes, such as alfalfa or red clover, are to be grown.

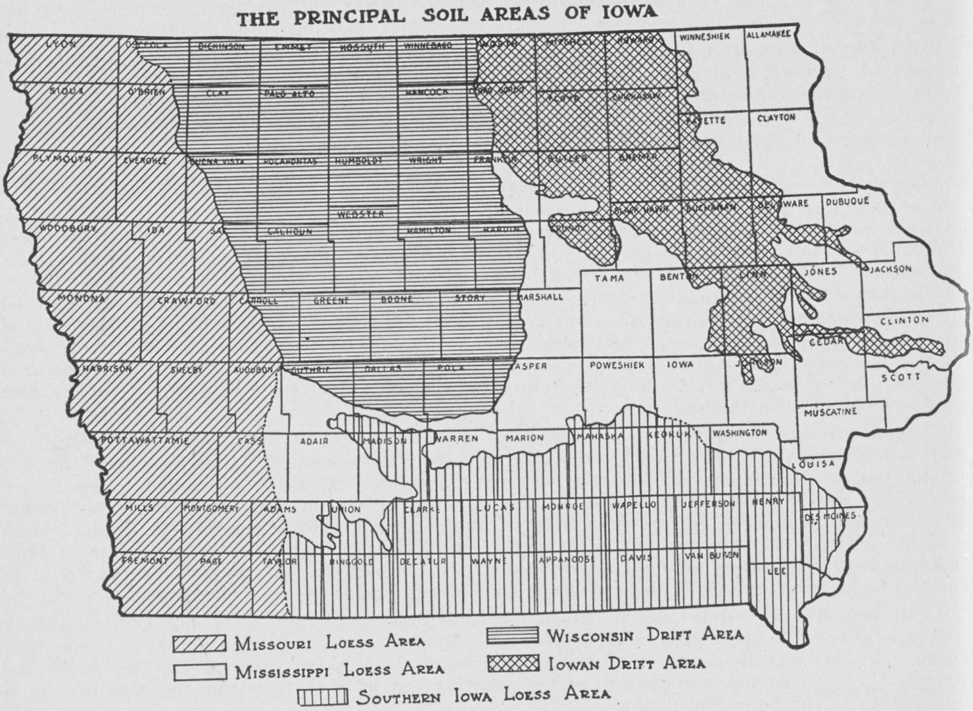
SOIL AREAS IN IOWA

There are five large soil areas in Iowa, the Wisconsin drift, the Iowan drift, the Missouri loess, the Mississippi loess and the Southern Iowa loess. These five divisions of the soils of the state are based on the geological force which brought about the formation of the various soil areas.

With the exception of the northeastern part of the state, the whole surface of Iowa was in ages past overrun by great continental ice sheets. These great masses of ice moved slowly over the land, crushing and grinding the rocks beneath and carrying along with them the material which they accumulated in their progress. Five ice sheets invaded Iowa at different geological eras, coming from different directions and carrying, therefore, different rock material with them.

The deposit, or sheet of earth debris left after the ice of such glaciers melts, is called "glacial till" or "drift" and is easily distinguished by the fact that it is usually a rather stiff clay containing pebbles of all sorts as well as large boulders of "niggerheads." Two of these drift areas occur in Iowa today, the Wisconsin drift and the Iowan drift, covering the north central part of the state. The soils of these two drift areas are quite different in chemical composition, due primarily to the different ages of the two ice invasions. The Iowan drift was laid down at a much earlier period and is somewhat poorer in plant food than the Wisconsin drift soil, having undergone considerable leaching in the time which has elapsed since its formation.

THE PRINCIPAL SOIL AREAS OF IOWA



Map showing the principal soil areas in Iowa.

The drift deposits in the remainder of the state have been covered by so-called loess soils, vast accumulations of dust-like materials which settled out of the air during a period of geological time when climatic conditions were very different from the present. These loess soils are very porous in spite of the fine texture, and they rarely contain large pebbles or stones. They present a strong contrast to the drift soils, which are somewhat heavy in texture and filled with pebbles and stone. The three loess areas in the state, the Missouri, the Mississippi and the Southern Iowa, are distinguished by differences in texture and appearance, and they vary considerably in value for farming purposes. In some sections the loess is very deep, while in other places the underlying leached till or drift is very close to the surface. The fertility of the soils and their needs are greatly influenced, therefore, by their depth.

It will be seen that the soils of the state may be roughly divided into two classes, drift soils and loess soils, and that further division may then be made into various drift and loess soils because of differences in period of formation, characteristics and general composition. More accurate information demands, however, that further divisions be made. The different drift and loess soils contain large numbers of soil types which vary among themselves, and each of these should receive special attention.

THE SOIL SURVEY BY COUNTIES

It is apparent that a general survey of the soils of the state can give only a very general idea of soil conditions. Soils vary so widely in character and composition, depending on many other factors than their source, that definite knowledge concerning their needs can be secured only by thorough and complete study of them in place in small areas. Climatic conditions, topography, depth and character of soil, chemical and mechanical composition and all other factors affecting crop production must be considered.

This is what is accomplished by the soil survey of the state by counties, and hence the needs of individual soils and proper systems of management may be worked out in much greater detail and be much more complete than would be possible by merely considering the large areas separated on the basis of their geological origin. In other words, while the unit in the general survey is the geological history of the soil area, in the soil survey by counties or any other small area, the unit is the soil type.

GENERAL SOIL CHARACTERISTICS

Soil types possess more or less definite characteristics which may be determined largely in the field, although some laboratory study is necessary for final disposition. Usually the line of separation between adjoining soil types is quite distinct and it is a simple matter to locate the type boundaries. In some cases, however, there is a gradation from one type to another and then the boundaries may be fixed only with great difficulty. The error introduced into soil survey work from this source is very small and need cause little concern.

The factors which must be taken into account in establishing soil types have been well enumerated by the Illinois Experiment Station in its Soil Report No. 1. They are:

1. The geological origin of the soil, whether residual, glacial, loessial, alluvial, colluvial or cumulose.
2. The topography or lay of the land.
3. The structure or depth and character of the surface, subsurface and subsoil.
4. The physical and mechanical composition of different strata composing the soil, as the percentages of gravel, sand, silt, clay and organic matter which they contain.
5. The texture of porosity, granulation, friability, plasticity, etc.
6. The color of the strata.
7. The natural drainage.
8. The agricultural value based upon its natural productiveness.
9. Native vegetation.
10. The ultimate chemical composition and reaction.

The common soil constituents may be given as follows:†

Organic matter	All partially destroyed or decomposed vegetable and animal material.
Inorganic matter	Stones—over 32 mm.* Gravel—32—2.0 mm. Very coarse sand—2.0—1.0 mm. Coarse sand—1.0—0.5 mm. Medium sand—0.5—0.25 mm. Fine sand—0.25—0.10 mm. Very fine sand—0.10—0.05 mm. Silt—0.05—0.00 mm.

SOILS GROUPED BY TYPES

The general groups of soils by types are indicated thus by the Bureau of Soils.

Peats—Consisting of 35 percent or more of organic matter, sometimes mixed with more or less sand or soil.

Peaty Loams—15 to 35 percent organic matter mixed with much sand and silt and a little clay.

Mucks—25 to 35 percent of partly decomposed organic matter mixed with much clay and some silt.

Clays—Soils with more than 30 percent clay, usually mixed with much silt; always more than 50 percent silt and clay.

Silty Clay Loams—20 to 30 percent clay and more than 50 percent silt.

Clay Loams—20 to 30 percent clay and less than 50 percent silt and some sand.

Silt Loams—20 percent clay and more than 50 percent silt mixed with some sand.

Loams—Less than 20 percent clay and less than 50 percent silt and from 30 to 50 percent sand.

Sandy Clays—20 percent silt and small amounts of clay up to 30 percent.

Fine Sandy Loams—More than 50 percent fine sand and very fine sand mixed with less than 25 percent very coarse sand, coarse sand and medium sand, much silt and a little clay; silt and clay 20 to 50 percent.

Sandy Loams—More than 25 percent very coarse, coarse and medium sand; silt and clay 20 to 50 percent.

Very Fine Sand—More than 50 percent fine sand and less than 25 percent very coarse, coarse and medium sand, less than 20 percent silt and clay.

Fine Sand—More than 50 percent fine sand and less than 25 percent very coarse, coarse and medium sand, less than 20 percent silt and clay.

* 25 mm. equals 1 in. † Bureau of Soils Handbook.

Sand—More than 25 percent very coarse, coarse and medium sand, less than 50 percent fine sand, less than 20 percent silt and clay.

Coarse Sand—More than 25 percent very coarse, coarse and medium sand, less than 50 percent of other grades, less than 20 percent silt and clay.

Gravelly Loams—25 to 50 percent very coarse sand and much sand and some silt.

Gravels—More than 50 percent very coarse sand.

Stony Loams—A large number of stones over 1 inch in diameter.

METHODS USED IN THE SOIL SURVEY

It may be of some interest to state briefly the methods which are followed in the field in surveying the soils.

As has been indicated the completed map is intended to show the accurate location and boundaries, not only of all soil types but also of the streams, roads, railroads, etc.

The first step, therefore, is the choice of an accurate base map and any official map of the county may be chosen for this purpose. Such maps are always checked to correspond correctly with the land survey. The location of every stream, road and railroad on the map is likewise carefully verified and corrections are frequently necessary. When an accurate base map is not available the field party must first prepare one.

The section is the unit area by which each county is surveyed and mapped. The distances in the roads are determined by an odometer attached to the vehicle, and in the field by pacing, which is done with accuracy. The directions of the streams, roads, railroads, etc., are determined by the use of the compass and the plane table. The character of the soil types is ascertained in the section by the use of the auger, an instrument for sampling both the surface soil and the subsoil. The boundaries of each type are then ascertained accurately in the section and indicated on the map. Many samplings are frequently necessary, and individual sections may contain several soil types and require much time for mapping. In other cases, the entire section may contain only one soil type, which fact is readily ascertained, and in that case the mapping may proceed rapidly.

When one section is completed, the party passes to the next section and the location of all soil types, streams, etc., in that section is then checked with their location in the adjoining area just mapped. Careful attention is paid to the topographic features of the area, or the "lay of the land," for the character of the soils is found to correspond very closely to the conditions under which they occur.

The field party is composed of two men, and all observations, measurements and soil type boundaries are compared and checked by each man.

The determinations of soil types are verified also by inspection and by consultation with those in charge of the work at the Bureau of Soils and at the Iowa Agricultural Experiment Station. When the entire county is completed, all the section maps or field sheets are assembled and any variations or questionable boundaries are verified by further observations of the particular area.

The completed map, therefore, shows as accurately as possible all soils and soil boundaries, and it constitutes also an exact map of the county.